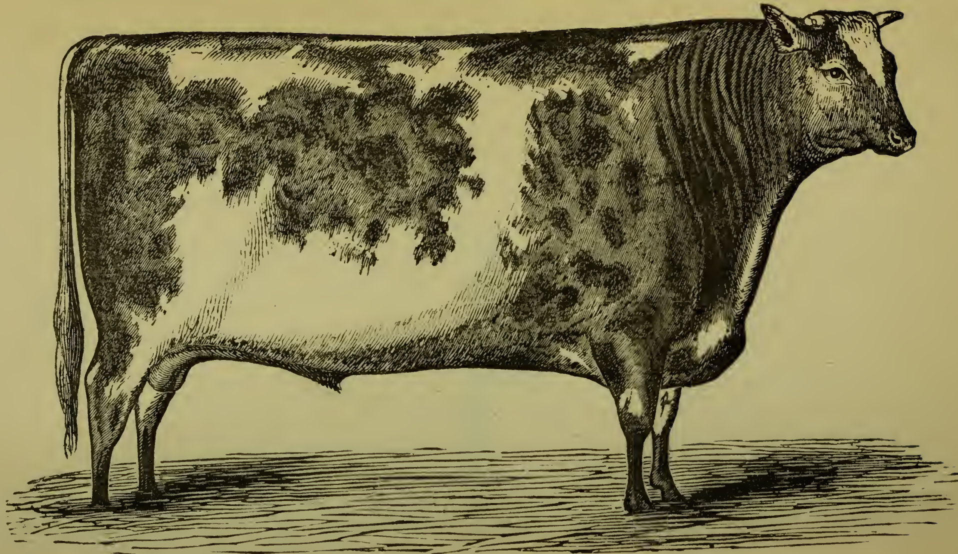

PRIZE YEARLING SHORT-HORN BULL, "VICTOR EMMANUEL,"

THE PROPERTY OF LORD TALBOT DE MALAHIDE,

Was awarded the First Prize in his Section (there being sixteen competitors), at the Show of the Royal Agricultural Society, held at Belfast, in August, 1861. Calved June 24, 1860; sire, Prince Duke the Second (16,731); dam, Turfoida, by Earl of Dublin (10,178); gd., Rosina, by Gray Friar (9,172); ggd., Hinda, by Little John (4,232).

HAND-BOOK

OF

FARM LABOUR.

BY

JOHN CHALMERS MORTON,

EDITOR OF "THE AGRICULTURAL GAZETTE," "THE AGRICULTURAL CYCLOPÆDIA," "THE NEW FARMER'S ALMANAC," ETC.

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HAND-BOOK

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FARM LABOUR.

THE following pages contain, re-arranged and in completer detail, the materials gathered for two papers, one of which, "On the Cost of Horse-Power," appeared in the nineteenth volume of the Royal Agricultural Society's Journal;* and the other, "On the Forces used in Agriculture," was read before the Society of Arts on the 7th of December, 1859, and immediately appeared in the weekly journal of that society. In addition to such a discussion of the management, the quantity, and cost of hand, horse, and steam power employed on English farms as may thus be possible, details are given of the expense of the different agricultural operations which are performed by means of them; and, founded upon these, the labour-cost is calculated of our different agricultural crops and products. The book was written originally seven years ago, and a new edition of it is supposed to be called for by the general interest which the condition of the agricultural labourer has of late excited. Such additions have accordingly been made to its pages as recent agricultural history and progress have made necessary.

I. STATISTICS OF FARM LABOUR.

IT is proposed in this chapter, in the first place, to specify the quantity of hand, horse, and steam power actually employed on a number of known farms, selected so as to be characteristic, as far as possible, of our different soils and our different styles of management; then to compare and contrast these instances, so as to determine how much horse and hand labour is employed per acre in good and average agriculture; and, lastly, to give such tables from the latest returns of the population and their

* Murray.

occupations as throw light upon the whole amount of farm labour in the country.

1. Labour on Light Soils.—I give three instances:—(1.) My first is that of an extremely light-soil farm reclaimed from Sherwood Forest in Nottinghamshire: It varies from a mere sand to a gravelly sand, in many places containing boulders. Its character is indicated by the fact that a day's ploughing is equal to one acre in the case of the deepest work, and 1½ or even two acres in that of light fallow ploughing—the average ploughing of all sorts being about 1¼ acres daily, done in eight or nine hours—two horses to a team. The extent of the land under cultivation is 930 acres, all arable: 350 acres are in grain crops; 350 are in one and two years' clover; twenty acres are in pulse crops; and 210 acres are in fallow crops, as turnip, mangold-wurzel, &c. Twenty horses suffice for the cultivation of the land, being one pair to every ninety acres; or, deducting the acreage in clover, one pair for every fifty-six acres of land actually under the plough. Steam power has latterly been employed, not only for threshing out the corn, but for cultivation. The following figures, however, refer to the labour of the farm under horse cultivation.

The average number of persons constantly employed is twenty-four men and eighteen boys. This, however, includes a foreman and a wheelwright. In harvest additional hands are hired for various periods. In July and August some thirty boys are engaged in singling turnips and in weeding. The wages paid during a selected year, deducting the wheelwright, were £1,245 12s. 2d.; in the following year, the wages paid were £1,147 8s. 11d. The extra harvest wages paid amounted, in the two years, to £156 17s. 7d., and £216 13s. 3d. respectively. The average sum annually paid for hand labour amounted thus to £1,383 5s. 11d., or as nearly as possible, 30s. per acre.

(2.) My next two instances are of comparatively light fen land, in the counties of Cambridge and of Lincoln. The following are the particulars given me of a farm near Chatteris. The soil is very light and non-adhesive; a character, however, which it is gradually losing by lapse of time, for many fen farmers break up a good deal of their clean fallow lands with four or six horses to a large plough, bringing up the subsoil, which is clay, and mixing it up with the top soil. They then plough from ten to fourteen inches deep; but the usual depth of ploughing is for wheat five or six inches; and on the higher lands they cultivate from six to eight or nine inches deep. Two horses easily plough

five roods a day on the fen; on the high lands early in the season two horses will plough from three to four roods per day; but in winter and spring, when the land gets wet and sticks a good deal, they usually plough with three horses at length, to avoid treading, and they plough just three roods daily.

The farm consists of 900 acres of plough land and 120 acres of pasture: 450 acres are in grain crops; 150 in clover; 65 in pulse (beans, peas, &c.); and 235 in fallow crops (turnip, mangolds, rape). The horses needed number twenty-nine—one pair for every sixty-two acres of arable land, or, taking clovers out, one pair for every fifty-two acres of actually ploughed land. The hands regularly employed are about thirty men throughout the year, and twenty to thirty women, girls, and boys, from April to November. Of this number, six men during winter, not so many in summer, are employed at piecework. Extra hands are employed for reaping and during harvest time, but at no other period. The wages paid amount to £1,560 a year; and it is to be taken into account, as affecting the amount of labour, that forty acres of potatoes are grown as one of the fallow crops, and that weeding on fen lands is an expensive item. This amount, deducting 5s. an acre for the pastures, is 34s. per acre on the arable land.

(3.) The following are particulars of another farm, also of fen land, but in which the process of ploughing up the clay subsoil has been carried further, so that the soil is peat upon clay over not more now than one-half of the farm—over the remainder the clay is ploughed up—and it needs a great deal of rolling to give it sufficient solidity for the wheat crop. The ploughing may be reported at $1\frac{1}{4}$ acres daily on the average for each pair of horses. The general depth of cultivation is five inches; for, though they plough deeper for fallow, yet the peat decomposes, and they lose the depth in the course of a year, and find it prejudicial to any other crop to plough deeper than it was fallowed.

The land is 790 acres in extent, or, deducting roads, and drains, and waste, 760 acres, of which about 100 acres are pasture, 130 are clover, 330 acres grain crops, 90 acres flax and pulse, &c., and 110 acres are fallow crops. Twenty horses are employed—one pair for every sixty acres of arable land, or, deducting clovers, one pair for every fifty-three acres of land actually under the plough. The wages paid for hand labour during the three years, were £1,414, £1,305, and £1,061, averaging £1,260; which, deducting 5s. an acre for the pasture land, is 37s. an acre. The number of men during three months from Lady-day averaged

twenty-eight weekly. During August, September, and October, they averaged about twenty-two, independently of which £300 were spent in harvest wages. During the remainder of the year they averaged about twenty. In addition to this, from sixteen up to nearly forty boys and girls, and from eight to twelve women, are employed during the spring and summer months. The whole labour during the three years referred to is represented in the following table, in which the work is given as occupying so many weeks of one man, woman, or child:—

Year.	Number of Weeks of one			Equal to Employment throughout the Year for so many.			Harvest Wages in addition.	Total Wages.
	Man.	Woman.	Boy or Girl.	Men.	Women	Boys or Girls.	£	£ s. d.
1st	1,312	210	651	25	4	12½	300	1,414 14 0
2nd	1,314	147	665	25	3	12½	300	1,304 16 9
3rd	1,164	131	660	22½	2½	12½	245	1,060 16 0
Average	1,263	163	659	24	3	12½	281	1,260 2 3

The use of steam power on these farms is confined to the work of threshing out the grain.

2. Labour on Medium Soils.—(1.) My first instance is that of a small farm, wholly arable, in Gloucestershire. It consists of 260 acres of a soil varying from a light and shallow stony brash over limestone rock to a somewhat clayey loam. There is a fixed steam-engine of about six-horse power, by which all the threshing is done, and seven horses did all the horse work of the farm during the time I knew it; and as all the root crops were carried home, and only one-eighth part of the arable land was in clover, the labour of cultivation was very heavy. This was equal to seventy-four acres of arable land, or about sixty-four acres, deducting the portion in clover, to each pair. I have the labour account of this farm for three years, during which the wages had averaged about £700, varying from £9 and £10 a-week during winter, to £14 and £15 during spring and summer, and £20 to £40 during harvest. Ten men during winter, and thirteen or fourteen in summer, with as many as fourteen or fifteen women and boys during the spring and summer season, and three or four during winter, were con-

stantly employed. The wages were to a great extent paid by the piece: as much as £200 out of £700 were thus paid. On the whole it amounted to nearly 54s. per acre, one of the largest expenditures in ordinary arable farming which I have known. (2.) The following particulars relate to a first-class arable farm in East Lothian:—Its extent is 650 acres; and it employs twenty-one work horses, or one pair for every sixty-two acres, which, deducting 120 acres of clover, is equal to one for about every fifty acres of land actually under the plough. No fewer than eighty acres are each year in potatoes, which has no doubt considerable influence on the manual labour bill. The following are the hands employed:—One overseer, one shepherd, ten ploughmen; three—engine-man, barn-man, and overseer of out-workers; two cattlemen, five hedgers and labourers, and thirty-five lads and women. Besides these, twenty-five or thirty people are employed for three or four weeks at harvest, and ten or twelve women are kept on until the potatoes are secured. Reaping machines have enabled the tenant to dispense with the labour of thirty or forty people during harvest time. The labour of this farm must cost at least £1,200 a-year, or nearly 40s. per acre. (3.) The following relates to a farm in Northumberland of 310 acres arable and 110 acres pasture, most of which is a flat alluvial soil, partly light and partly good deep loam—all good turnip land:—Fallows are ploughed eight to nine inches deep with two horses, and twelve inches with three horses wherever the land allows; lea land is ploughed four to 6½ inches deep; turnip land for corn five inches. Eight horses are needed, a pair for every seventy-eight acres of arable land, or, deducting fifty-seven acres of clover, one for every sixty-three acres of ploughed land. On this farm only seven men and nine women are employed regularly, and seven men and seven women for a month extra during harvest. The wages cannot exceed £500 a-year, or about 32s. an acre on the arable land. (4.) On a farm in Oxfordshire of 300 acres, 100 of which are meadow and the remainder gravel, clay, and clay loam, twenty-five acres being in clover, seven horses are employed, being a pair for every fifty-seven acres of arable, or for every fifty of *ploughed* land. The staff of labourers consists of fourteen men, five boys, and four women, all of whom, except the women, who do not turn out in bad weather, are employed throughout the year. All the farm work, harvest included, is done by the regular hands, the land being of such various character as to bring the harvest in at various periods so as to be easily manageable. The

labour bill here must be at least £450 a-year; or, deducting 5s. an acre for the pastures, upwards of 40s. an acre. (5.) The College farm at Cirencester is described as follows:—260 acres are a useful marl with stones; the soil deep enough to allow of seven-inch ploughing, and sufficiently retentive to render it stiff working land in moist weather; 100 acres are of a light and shallower soil, sometimes occupying the slopes of the hills, where there are not more than two or three inches of earth; forty acres are a strong clay marl. Three horses in line are needed for six to seven-inch ploughing. From one acre (lea ploughing) to three-quarters (in winter) is a day's ploughing. For working these 400 acres arable and forty acres pasture, eleven horses are required, equal to one pair for every seventy-two acres arable, or, deducting 100 acres of clover, for every fifty-four acres of actually *ploughed* land. The labour bill amounts to £700 a-year; or about 34s. 6d. an acre on the arable part of the farm. The labourers employed are as follows:—Team hands, three men, two young men, one boy; cattle hands, three men and one boy during four months, three men and three boys during eight months; day-labourers rather above eight on an average throughout the year; boys rather more than four; women rather above four on an average. (6.) Of two large farms near Lechlade, Wiltshire, I have particulars of the labour annually employed. They include no less than 2,000 acres of arable land, and 430 of pasture; and the following are the hands employed in July and in November respectively:—

	July.	November.
Men and Lads with Teams	51	40
Do. Do. ,, Sheep	8	14
Do. Do. ,, Cattle	5	11
Do. Labourers	53	45
Women	61	25

This will represent an average employment of 95 men, 20 boys, and 40 women throughout the year. The labour bill cannot fall short of £3,200 a year, or 32s. an acre on the arable land.

The horses employed on these farms, previous to the adoption of steam power for cultivation, were forty-three in number, with seven teams of oxen. If these oxen be put, as equal to thirteen

horses we shall have twenty-eight pairs to 2,000 acres of arable land, one to every 71 acres, or thereabouts; or, deducting about 500 acres of clover and some fern, a pair to every fifty-three acres of actually ploughed land.

(7.) My last instance under this class of soils is of a farm also on the Cotswold range, and for the most part of shallow brashy soil, consisting of rather more than 400 acres arable, and 280 acres pasture; twelve horses are employed, equal to one pair for every sixty-eight acres arable, or, deducting no less than 174 acres of clover, &c., one pair for only forty acres of actually ploughed land. The hand-work of the farm is done by twenty-three men, seven boys, and ten women, besides extra occasional hands for reaping, turnip-hoeing, and sundries. If we add £75 for this extra harvest work, the labour bill of this farm will probably exceed £750 annually, amounting to 34s. per acre of the arable land, if we deduct for the probable expenditure on the pastures.

3. Labour on Stiff Soils.—It is on these soils especially that steam power is likely to find general employment in the cultivation of the land. It will not, however, displace manual labour, for it will enable the cultivation of a more laborious class of crops—mangold-wurzel, for instance, in place of vetches—enabling thus the keeping of a larger live stock through the year, which will require a proportionally large number of attendants. I have four instances in illustration of the labour of stiff soils, and on most of them the steam plough is at work. (1.) Woolstone Farm in Buckinghamshire, for the most part a heavy soil (112 acres arable land, and seventy acres grass land), employs regularly three horses and a ten-horse power engine, which is employed on an average during fourteen days in ploughing, and during other fourteen days in threshing. Seven men and four boys are employed regularly on this farm, and their wages must amount to at least £250, or, deducting £20 a year for the pastures, £2 2s. per acre per annum. The horse labour on this farm is equal to one pair to every seventy-four acres of arable land, or (deducting twelve acres in clover) to every sixty-six acres of actually ploughed land. (2.) On a farm of 590 acres of arable land, sixty-five acres of water-meadow, and 160 acres of down-land, in Wiltshire, the labour bill amounts to about £1,170 a year, which, deducting for pasture-land, is about 38s. an acre. This pays for thirty-one men, seventeen boys, and fourteen women and girls. The horse labour on this farm is done by sixteen large cart-horses, and twenty-two ponies, the latter being worked three or four in a plough, and

reckoning them at their comparative value with ordinary cart horses, the whole may be considered equal in force to about twenty-eight of the latter. Of the 590 arable acres, 120 are in clover or other artificial grass; 120 are in roots or other summer and autumn food; and 350 acres are in corn, including turnip seed. (3.) On a clay land farm of 520 acres arable, and 200 acres pasture, there are employed, with slight variations, thirty men, seven women, and twelve boys, throughout the year, with seventy additional men for three weeks during harvest time. Twenty-four horses were employed, which was a pair for every forty-three acres of the arable land, until steam power was employed in cultivation. Since then, one-third (eight) less are needed from the termination of wheat sowing till the commencement of harvest; but the other part of the year (*i.e.* during harvest and during autumn cultivation of which, even with the aid of steam, enough cannot be done) gives work for as many horses as ever; so the difficulty is met in this way—four horses are parted with, and from the others four to six colts are annually bred, the foals are weaned early, and the mares are brought to work again just when they are wanted. The labour of the farm, calculated at ordinary wages, must cost £1,200 a year, which, after deducting for the pasture-land, is at least £2 4s. per acre. (4.) My fourth instance is of land near Farringdon, of which one-half is pasture, and the whole is a dairy farm. It is 600 acres in extent, and 150 cows are milked, which of itself requires fifteen constant hands. The whole hand labour of the farm costs nearly £800 a year, and is done by the following hands upon the average—twenty-two men, eight women, ten boys. Deducting for the pasture, the labour of the farm amounts to at least 46s. an acre over the arable land. An engine is used for threshing and cutting chaff for cattle, and grinding food for pigs; and a set of Fowler's steam-ploughing tackle is also found to answer exceedingly well in the cultivation of the land.

4. Average Quantity of Labour Employed.—Let us in the first place tabulate and compare the results already obtained.

The reader may be left to extract for himself what information the table can convey. It will, however, be right to say, that our first instance of a medium-soil farm must be considered as altogether exceptional; a very unusual proportion of the land was in laborious fallow crop, and not only was the quantity of hand labour unusually large, but the quantity of horse labour was unusually small. Taking those cases, of which the full particulars

Soils	No.		Extent in Acres. Arable. Fallow Crops.	Arable. Grain.	Arable. Clover.	Pasture.	Horses worked.	Hand Labour. Men.	Hand Labour. Women	Hand Labour. Boys and Girls.	Annual Labour Bill.	Wages per Acre of Arable, Deducting 5s. for Pasture.		Acres to each Pair of Horses. Arable Land.	Plough-ed Land	Fallow Crops.
											£	s.	d.			
Light Soils.	1	1	210	350	350	15	20	28	—	22	1383	30	0	90	56	20
		2	235	515	150	120	29	30	12	15	1560	34	0	62	52	16
		3	110	420	130	100	20	33	3	13	1260	37	0	66	53	11
Medium Soils.	2	1	70	160	30	—	7	12	8	4	700	54	0	74	64	20
		2	430		120	—	21	26	20	15	1200?	40	0	62	30	16?
		3	78	175	57	110	8	8	10	—	500?	32	0	78	63	19
		4	50	125	25	100	7	14	4	5	450?	40	0	57	30	14
		5	91	224	85	40	11	16	4	8	700	34	6	72	54	16
		6	566	946	492	430	56	95	40	20	3200?	32	0	71	53	10
		7	60	174	174	280	12	25	12	8	750?	34	0	68	40	10
Heavy Soils.	3	1	20	80	12	70	3	7	—	4	250?	42	0	74*	16	14
		2	120	350	120	225	28	31	14	17	1170	38	0	42	33	9
		3	120	280	120	200	20	34	7	12	1200?	44	0	52*	40	12
		4		300		300	—	22	8	10	800	46	0	—*	—	—

On the farms marked thus * much of the cultivation is done by the Steam Plough.

are given—viz., thirteen out of the fourteen farms described—we have the following gross results :—On 7,824 acres of arable land,

and 1,690 of pasture, 242 horses are employed, and work is given to 359 men, 134 women, and 143 boys and girls, costing, on the whole, not less than £14,323. This, if we deduct £423 for the pastures, is equal to about 33s. per acre of arable land. The horse labour of these farms amounts, on the average, to one pair for every sixty-five acres of arable land, or for every forty-nine acres of actually ploughed land.

It will be observed that more than the average wages are paid for manual labour on those farms where steam power is employed as an auxiliary force. The interests of the labourer will be considered more fully in a subsequent chapter, and the possibility of his suffering by the employment of a cheaper force and more powerful machinery will be discussed. Meanwhile it is a fact, that on those farms of which the details are known, where steam power is employed for cultivation, the wages paid for manual labour exceed the average. And if it be alleged that this is a consequence of the stiffer nature of the soil in those cases, the rejoinder is, that this intractability of soil has hitherto resulted in such land being kept in pasture, or, when cultivated, being devoted only to such crops as grain, vetches, clovers, which involve the least manual labour in their cultivation, whereas, where steam power is available for cultivation, our clays, retaining their superior fertility, are made available for all kinds of fallow, labour-giving crops, such as mangold-wurzel, kohl rabi, cabbages, and other winter food for sheep and cattle.

And there is, thus, extra labour needed not only in their cultivation, but also in tendance of the live stock needed for the consumption of their produce.

It must be remembered by any who would apply these results over any great extent of country, in order to ascertain the quantity of our agricultural labour, that the farms quoted are much above the average, whether as regards the intelligence, the enterprise, or the wealth of their occupants; and, therefore, no doubt much above the average as regards the force employed in their cultivation. Probably a more useful set of averages for statistical purposes exists in certain results which I obtained some years ago by an agricultural survey of south Gloucestershire. That county, and especially that section of the county, is remarkable for an extremely various geology. The extent of the several geological districts which it comprises was estimated and ascertained (after they had been laid down on the ordnance map) by scale and compasses; the extent of pasture land in each was estimated on

data obtained by careful observation; the quantity under the several crops was calculated by applying the common rotation of each district to the extent of arable land within it. The average produce of these crops was judged of by many seasons' observation, and some experience; the total value of agricultural produce was thus obtained, and its value per acre was divided, according to the best judgment that could be formed, amongst the three parties interested in it, viz., the Landlord, Labourer, and Farmer. The following are the results arrived at:—

AGRICULTURAL STATISTICS OF SOUTH GLOUCESTERSHIRE.

No.	Soil of the Several Districts.	Per Centage of Arable Land.	Value of Gross Produce per Acre.			Rent.			Labour.			Profit.		
			£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
1	Clay-loam	3	3	13	0	2	6	0	0	12	6	0	14	6
2	Stiff clay........	4	2	4	0	1	0	0	0	12	0	0	12	0
3	Marl and loam	14	3	0	0	1	8	0	0	18	0	0	14	0
4	Medium	17	3	12	0	1	10	0	1	6	0	0	16	0
*5	Rich loam	30	*4	17	0	*1	18	0	*2	4	0	0	15	0
6	Poor clay	37	3	3	0	0	18	0	1	12	0	0	13	0
7	Brashy soil......	42	3	16	6	1	5	0	1	15	6	0	16	0
8	Light gravel ...	50	3	13	0	1	16	0	1	1	0	0	16	0
9	Light soil	50	3	1	0	1	6	0	1	1	0	0	14	0
10	Ditto	60	4	0	0	1	10	0	1	13	6	0	16	0
11	Thin brash......	86	3	18	0	1	17	0	1	17	0	0	14	0
12	Light soil	100	4	12	0	1	12	0	2	5	0	0	15	0

It must be remembered that the labour column includes the whole cost of cultivation—horse labour as well as manual labour—and the amount paid in wages is therefore to be sought by deducting from the sums specified in that column such a number of shillings per acre as the horse labour may be estimated at. I do not name the districts, or give their geological character or position; they are arranged in the order of the proportion of arable land which they are believed to contain.

If, now, the horse labour be taken at 20s. an acre where the land is wholly arable, and reduced to 10s. where 50 per cent. of the land is arable, and to 5s. or 6s. an acre or thereabouts where it is wholly pasture, the wages paid per acre in south Gloucestershire will vary from 6s. 6d. per acre to as much as 25s. an acre

* A great deal of potato cultivation prevails.

on the richest and most arable soil; amounting in all to probably not more than 21s. an acre over the whole district, and to not more than 24s. or 25s. over the arable land of the district. This is, however, considerably under the average of the farms, whose particulars have been given.

5. National Statistics relating to Agricultural Labour.—Premising that of the whole population of England and Wales (20,066,234 in 1861), about 25 per cent., or probably rather less, may be stated to be engaged in agriculture, I quote from the census table of 1861 the following table of the numbers engaged in the several departments of farm work:—

EMPLOYMENTS OF THE AGRICULTURAL CLASS IN 1861.

1861.	Males.	Females.
a. IN FIELDS AND PASTURES.		
Proprietors	15,131	15,635
Farmers, Graziers	226,957	22,778
Farmers' and graziers' wives	—	163,765
Farmers' sons, daughters, &c.	92,321	83,830
Farm bailiffs	15,698	—
Agricultural labourers (out-door)... ...	914,306	43,964
Shepherds	25,559	—
Farm servants (in-door)	158,401	46,561
Land surveyors, Land agents	4,702	—
Agricultural students	490	—
Hop growers	33	—
Willow growers	35	—
Teazle growers	81	—
Agricultural implement proprietors ...	236	—
,, ,, workers	1,205	—
Drainage service	1,761	—
Colonial farmers	91	—
Others	73	44
b. IN WOODS.		
Woodmen	8,907	—
Others	10	9
c. IN GARDENS.		
Gardeners	76,700	1,773
Nurserymen...	2,838	79
Watercress growers	55	—
Others	22	5

I have given the whole series of figures characteristic of the agricultural class, notwithstanding that many items in these columns have no relation to the agricultural labourer. The principal items are those of in-door servants, and out-door farm servants and shepherds, and I repeat them, dividing them into columns determining their ages.

Labourers	Total.	Under 20 Years Old.		Over 20 Years Old.	
		Males.	Females.	Males.	Females.
Out-door	1,077,627	198,226	14,826	808,502	56,072
In-door	364,194	126,491	64,713	109,452	63,538
Shepherds	19,075	2,990	—	16,085	—
Total	1,460,896	327,707	79,539	934,039	119,610

NUMBER OF LABOURERS EMPLOYED ON FARMS OF VARIOUS SIZES.

1. Number of Labourers employed by each Farmer.	2. Number of Farmers employing the Labourers in Column 1.	3. Number of Labourers employed by the Farmers in Column 2.
0	91,698	—
1	33,564	33,564
2	27,949	55,898
3	17,348	52,044
4	14,109	56,436
5	7,622	38,110
6	6,449	38,694
7	3,849	26,943
8	3,806	30,448
9	2,423	21,807
10	8,632	107,900
15	3,221	56,367
20	2,073	46,642
25	850	23,375
30	721	23,433
35	256	9,600
40	275	11,687
45	106	5,035
50	132	6,930
55	65	3,738
60 and upwards.	170	17,000
Total	225,318	665,651

The foregoing table, illustrative of the varying numbers of labourers employed on farms of different sizes, has been given, though it is taken from the census of 1851, because it still, in all probability, nearly represents the truth. The table states that 91,698 farmers made no return of the number of labourers on their farms. In the majority of such cases it may be assumed that no labourers were employed by them; that number of small farms being worked by the occupants alone. The Table reads thus:—7,622 farmers employ five labourers apiece, or 38,110 labourers in the aggregate, and so on.

To this another table may be added, in which a return is given of the number of farms of various sizes in England, Scotland, and Ireland respectively. The return for Ireland is dated 1861, and those for England, Scotland, and Ireland date from so long ago as 1857, when the agricultural statistics of Scotland were last collected by the Highland and Agricultural Society.

SIZE OF FARMS AS INDICATING OCCASION FOR AGRICULTURAL LABOUR.

Size of Farms.	Ireland.	England and Wales.	Scotland.	Islands.
Under 5 Acres.	127,030			
5 to 15 ,,	183,931			
15 ,, 30 ,,	141,251			
30 ,, 50 ,,	72,449			
50 ,, 100 ,,	53,930			
Under 100 ,,	578,591	142,358	44,469	3,746
100 to 200 ,,	21,531	45,752	7,009	151
200 ,, 300 ,,		18,401	2,166	36
300 ,, 400 ,,	8,329	8,061	961	9
400 ,, 500 ,,		3,585	471	7
500 ,, 600 ,,		1,971	272	5
600 ,, 1,000 ,,	1,591	2,372	442	2
1,000 and upwards		771	360	1
Total	610,045	223,271	56,150	3,957

In the above table most of the smaller holdings in Great Britain are omitted. Their number in Ireland will, no doubt, ultimately diminish by the prevalence of a better agriculture, and the consequent union of small farms—the smaller tenantry earning

a better livelihood as labourers. Two-thirds of the farms in Great Britain at the date in question were under 100 acres; or, taking the exact proportion—in 1,000 farms 672 were under 100 acres, 187 were between that and 200 acres, 137 were 200 and under 1,000, and four were 1,000 acres and upwards. The proportions to 1,000, farms in England and Wales were 638 under 100 acres, 205 of 100 and under 200 acres, 154 of 200 and under 1,000 acres, and three of 1,000 acres and upwards. In Scotland there were 360 farms, and in England 771 of 1,000 acres and upwards; and there were 142,358 farms in England, and 44,469 farms in Scotland, each of which is under 100 acres. In England and Wales the large holdings abound in the south-eastern and eastern counties; the small farms in the north midland counties, in Yorkshire, in Wales, and in the north-western counties, comprising Lancashire and Cheshire.

6. Agricultural Statistics as indicating Employment of Labourers in Agriculture.—The following figures give the latest agricultural statistics (1867). They are confined to such particulars as may illustrate the subject of farm labour, giving the acreage of corn and green crops and of grass respectively, in the several divisions of the country:—

	England.	Wales.	Scotland.	Ireland.	Total for United Kingdom.*
Total Population	20,276,494	1,187,103	3,136,057	5,571,971	30,315,072
Total Area (in Statute Acres)	32,590,397	4,734,486	19,639,377	20,322,641	77,513,585
Abstract of Acreage:—					
Under all kinds of Crops, bare fallow, and Grass	22,932,356	2,519,170	4,379,552	15,542,208‡	45,491,097
Under Corn Crops	7,399,347	521,404	1,364,029	2,115,137	11,431,940
,, Green Crops	2,691,734	138,387	668,042	1,432,252	4,951,796
,, Bare Fallow	753,210	86,257	83,091	26,191	953,998
,, Grass—Clover, &c., under rotation ...	2,478,117	300,756	1,211,101	1,658,451	5,679,433
Permanent Pasture, not broken up in rotation† ...	9,545,675	1,472,359	1,053,285	10,057,072	22,156,541
Abstract of Live Stock returned:—					
Total Number of Cattle ...	3,469,026	544,538	979,470	3,702,378	8,731,473
,, ,, of Sheep ...	19,798,337	2,227,161	6,893,603	4,826,015	33,817,951
,, ,, of Pigs ...	2,548,755	229,917	188,307	1,233,893	4,221,100

* Including Islands. † Exclusive of heath or mountain land.
‡ Including under Flax, 253,105 acres.

In addition to these figures I add the number of horses given in the latest returns open to us—viz., In England (1854), 1,309,010; in Scotland (1857), 185,409; and in Ireland (1867), 322,348.

Now, excluding the Irish returns, we have nearly 18,000,000 acres under arable culture, and probably 12,000,000 in permanent pasture. If there be a pair of horses for every fifty acres of plough land in the country, employment is at once provided for 720,000 horses, leaving about 770,000 unaccounted for, a number which, including colts and young animals, is not greater than are no doubt used as hacks, carriage horses, and in commercial traffic. Suppose, again, that the wages of agricultural labourers amounted to 28s. an acre on the arable land, and 7s. 6d. an acre on the pasture, which is midway of the instances already quoted: we then have an agricultural labour bill of nearly £30,000,000. Now there are 824,587 labouring men engaged in out-door work in English agriculture, and supposing them to earn 11s. a week apiece throughout the year, their wages will cost £24,583,187. There are 56,072 female agricultural labourers, and if they work about half the year at 5s. a week, they will earn about £7 each, or £392,504. There are 201,216 boys and 14,826 girls set down as agricultural labourers; if half of them are constantly employed at 5s. a week throughout the year, they will cost about £1,400,000. And these sums amount to upwards of £26,000,000, But there are large numbers of in-door servants put down as farm servants. 109,452 men, 63,538 women, 364,194 boys, and 126,491 girls are thus put down. A large part of this number are probably domestic servants; if the men, however, be taken as agricultural labourers, they, at 11s. a week will cost upwards of £3,000,000, and a large proportion of the boys will be paid for by another million, which, with the £26,000,000 already accounted for, just makes up the £30,000,000, at which, according to the estimated agricultural acreage of Great Britain, the manual labour of cultivation will amount to at the rate of £1 8s. per acre of the arable land, and 7s. 6d. an acre of the pasture. These, therefore, may be considered fair estimates of the annual expenditure per acre on agricultural labour in this country.

The information given in this chapter is related somewhat unconnectedly. Its estimates and facts are stated individually and separately; and the reader is left to choose those of them for his instruction or his guidance whose circumstances may most nearly resemble his own. Some further attempt will be made in the succeeding chapters on steam, and horse, and hand power

respectively, to justify the estimates already made of the quantity of each already used in English agriculture, as well as to indicate such alterations in the quantity and quality of each as will probably arise in farm practice as time goes on.

II. STEAM—WATER—WIND.

THE reader must be referred to other works* for information about those points in the relations of water to heat on which the theory of steam power depends, as well as for those details of the construction of steam engines which have been devised in order most fully to realise in practice all that theory points out as possible in the economy of fuel and in the production of force.

He must also consult works on hydraulics,* both theoretical and practical, for such instruction as will enable any one to turn a water supply to account, by means of water-wheel or turbine, in the production of power. The present chapter will be confined to general remarks on the availability of these powers for agricultural purposes; on their ordinary cost per horse power under given circumstances; and on the economical use and management of each.

7. The Agricultural Uses of Steam Power.—It has long been used for grinding corn, cutting chaff, and threshing grain; latterly it has come, and every year with increasing rapidity it is now coming, into use for cultivating the soil.

There are three classes under which all the operations of the farm may be arranged, and they correspond exactly to the three principal forces which we have at our command.

In the first, where the greatest uniformity of process obtains, the greatest power is needed, and a purely mechanical force acting through levers, wheels, and pulleys, is in this way sufficiently under our control for their performance, and this class of operations increases in extent and in importance with almost every permanent improvement of the land, *i. e.*, with everything which tends to the uniformity of its condition. In the second class as much force is needed; but rocky subsoil, awkward hedgerows, crooked roads, and scattered produce interfere with

* For instance, to *The Engineers' Assistant*, published by Blackie and Son, Glasgow.

any possibility of uniform procedure. Some machinery, more pliable than cranks and rods, is needed by which to carry out the purpose of the mind, and here, therefore, it must work by means of the *teachable* and powerful horse. This class of operations diminishes in extent and importance with every permanent improvement of the soil, *i.e.*, with every removal of those obstacles to which I have referred. In the third class the care and cultivation of individual life, vegetable and animal, are concerned : no great power is needed, but there is need for the constant and immediate exercise of the will, varying, it may be, at every successive moment; and here, therefore, the human mind can work only by its most perfect instrument—the human hand. It is plain that everything by which on the one hand land is brought to a uniform condition, and by which, on the other, the quantity of its living produce is increased, will extend the first and last of these three fields of agricultural operations, and will diminish the necessity of employing horses.

And this is no mere speculation; it is the principal lesson of the agricultural experience of the past few years. If we knew for several successive years exactly the employment of our agricultural labourers (its nature, its quantity, and its reward) on each of the farms which make up the surface of Great Britain; and if we also knew the quantity and the manner, during all these years, of the horse labour of all these farms, its cost per acre and its effect; and if in addition to all this information we had the full experience, now very considerable, of the use of steam power upon the farm, not only for threshing and grinding and cutting, but for cultivating the soil, we should certainly learn from it how rapid has been the extension of those circumstances under which steam cultivation becomes possible. It is, indeed, more especially in the application of steam power to cultivation, that the great interest taken in its agricultural usage centres now. For this purpose it has special advantages over the horse, which may be named at once.

I refer first to the injury done to the land by the trampling of draught animals; and secondly, to that irregularity of employment on the farm for horses during the year, which in effect makes it necessary to keep upon a large farm several horses all round the year for the sake of their work during a few weeks of spring and autumn. If a steam engine, which costs nothing when it is idle, can be used to take this extra work, and so reduce the horse labour of the farm to an uniform monthly amount, then its cost

has to be compared, not with that of the horses which it has displaced during the few weeks in question, but with the cost of those horses throughout the year. It is this fitness of the engine for the cultivation of our stubbles in autumn, and so its power to displace so many teams throughout the year which would otherwise be kept just for the few weeks of most laborious time, that greatly heightens the economy of its employment.

It is, of course, on large farms, where three or four pairs of horses may be dispensed with without incurring any difficulty at harvest-time that steam power is most applicable; but even on small farms of clay-land the superiority of the tillage done by steam is so great that the advantage is cheaply bought, though a considerable additional annual charge is thereby incurred. It is on heavy soils, moreover, that the expense of horse labour—which the substituted steam must on farms of any size to a considerable extent displace—is greatest. Large teams must on such land be kept all the year round for the sake of their work during those few months of the year when they can be allowed upon the land; during which, moreover, there are days and weeks when, urged by the lapse of the season, the farmer permits his teams to work in unfit or barely fit conditions of the land. A power for tillage which will use more rapidly than horses the seasons of fitness; which will, moreover, unlike horses, work the land without treading on it; and, unlike horses, will incur no cost when not at work, must and does exhibit its greatest superiority on clay-land.

In a standard work on "The Valuation of Rents and Tillages" (Bayldon), the cost of the first year of the course of clay-land cropping is estimated thus:—

	£	s.	d.
First ploughing in winter	0	10	0
Second ploughing in spring	0	9	0
Harrowings, &c.	0	5	3
Third ploughing with harrowings	0	14	0
Fourth ploughing with the manure	0	8	0
Fifth ploughing	0	8	0
Seed furrow (8s.), &c.	0	12	9

This is the tillage pursued in bare-fallowing clay-land under ordinary horse cultivation. It is plain that six ploughings by a team of three horses, with a probability, almost certainty, that some at least of these operations will be driven into a time when such land is in unfit condition for cultivation, must be a most

costly and inefficient tillage. Every time that such a team has crossed the field something like two tons (man and tool and horses) have slid and tramped from one end of the land to the other; and in ploughing, this has been done once to every ten or twelve inches in width. Of course, this must harden the ground; and to any one who, without a practical knowledge of farming operations, merely reasons from the natural tendencies of things, it must appear the most clumsy and unlikely process for attaining tilth.

"What," might not such an one ask of the clay-land farmer, "is the object of those long teams of cattle that I see traversing your fields all through the summer, going to and fro twice for about every yard in width of the field they traverse? Are you aiming at the hardening and consolidation of the land?" "Certainly not," is the reply; we are ploughing the land, lifting the soil, exposing a fresh surface to the sun and air. What we aim at by these means is to mix and lighten up the layer of earth in which we place manure for the growth of plants; to soften and reduce it so that the seeds we sow there may be covered, each of them, by moistened particles smaller than itself; to feed and mellow it, so that the young plants shall spread their roots abroad without difficulty, and find the food they need." "Well! but," may not the answer be?—"these teams, with the men and boys and tools belonging to them, weigh 40 cwts. apiece, and to take those 40 cwts. tramping and sliding along every ten-inch width of the soil you want to 'lighten up' and 'soften' is an odd way of aiming at such an end, is it not?" The answer which is given to this is not satisfactory. "We well know," it is replied, "that there is nothing like treading with teams of horses or of oxen for hardening the ground. Indeed, when the land is loose about the young wheat-plant, it is, in some districts, in the early spring, a common practice to adopt that mode of hardening it; but in ploughing they walk in the furrow, and the tool, too, slides along in their wake *below* the layer of earth we move, which, therefore, may be lifted, broken, and loosened, untrodden, notwithstanding we are forced to use a team and a tool which must harden what they tread upon." This answer does not satisfy the querist, neither ought it to do so. It presumes upon a distinction between soil and subsoil which does not naturally exist, but is the result of the artificial treatment of both in common horse-tillage. The creation of a hardened floor beneath the former and above the latter, which in great measure cuts off the connection between the

two, is a real injury to fertility; and the destruction of this pan or indurated layer by steam power is one of the greatest benefits of steam-cultivation. The thorough drainage of clay soils is thus enabled; the material of the subsoil is thus added to the scanty supplies of the shallow layer which has hitherto fed our crops; the whole warehouse and machinery by which the work of plant-feeding has hitherto been accomplished is enlarged and energised, and an immense increase of fertility has been obtained. This is no mere theory or speculation; it has been realised in many instances, and realised in its most striking examples at a diminished cost. In place of six ploughings, by which horse tillage achieves its imperfect result, a single thorough smashing up, before winter, of land which has been well cleaned after harvest, is all that well-drained clay-land needs. I certainly do not assert this as a rule without exception; but of calcareous clays, at any rate, it may be asserted that, once drained and cleaned, a smashing up in dry weather before winter is better than a series of ploughings in the spring and early summer. This rough cultivation, followed by a winter's frost, is all that such land needs beyond the mere surface-preparation of the seed-bed in the spring, and that is work for the cultivator and the harrow. Mr. John Fowler said truly on this point, at a discussion before the London Farmers' Club, that a comparison of the cost of the one operation by steam power with that of a corresponding operation by horse power was most inadequate; that one steam-cultivation was equivalent not to one, but to a whole series of operations by horse power; and this not only for its tillage effects, but for its efficiency in the destruction of weeds. "When horses go a second time over the land, they plant as much couch in it as they plough out of it, so that it is impossible to clean land so thoroughly by horses as by steam."

It is, however, to its effect in producing tilth that one chiefly looks as the great result of steam cultivation. There is, as was stated in the paper read on the occasion just referred to, abundance of plant-food down below the level to which horse tillage extends; and so it must, of course, be conceded there is plenty of it below even the level—though that is much deeper—to which steam tillage extends. The main difference between the two lies not in the greater depth to which so great a power as steam can work the land, though that is a most important consideration, but in the fact that horses trampling in the furrow along which the tool they draw has gone, do harden a layer of earth above the

storage which is in their case thus cut off; and this makes the access both of the air which would fertilise this mass of earth below it, and of the roots which would then feed upon the material thus fitted for their food, less practicable and easy. In steam tillage, where the power stands off the ground, and is conveyed by a long rope to the tool—where the tool itself is carried on large wheels—this mischief, whether it be poaching the ground which is thus moved, or hardening a floor immediately below it over the earth which is not being moved, altogether disappears. And it is not too much to say that a clay soil deeply drained, and then deeply stirred and cultivated in dry weather by steam power, is in altogether different circumstances from any which before all this it had ever experienced.

The availability of steam power for the deepest cultivation, and its applicability at the same time to the thorough cultivation of any depth to which it may be desired to stir or turn the soil, without any pressure on it except by the wheels of the implement employed, must ultimately obtain for it the preference over horses for all mere ploughing and stirring, especially of clay-land. And a very large share of the horse labour of ordinary agriculture will thus be handed over to the steam engine.

In order to ascertain how much, let me first say that all the draught labour of the farm may, it is evident, be easily considered as so much weight drawn as if over a pulley (*i.e.* lifted) so many feet in a given time. Thus, the power exerted by a horse is assumed, on the authority of experiment, equal to the pull or lift of 33,000 lbs. one foot per minute; and to this agricultural experience agrees, for if a pair of horses draw a plough along with an average pull of 300 lbs. at an average rate of 2½ miles an hour, *i.e.* of 220 feet per minute, it is the same as if those 300 lbs. were pulled over a pulley, *i.e.* lifted that height in that time; and 300 lbs. lifted 220 feet per minute are just the same as 66,000 lbs. lifted one foot high per minute, which, as the performance of a pair of horses, is exactly the 33,000 lbs. apiece at which their force is valued by the engineer.

Now, I have had described to me the cultivation of certain farms in such detail that all the ploughing, scarifying, harrowing, rolling, horse hoeing, carting, &c.—all the horse labour, in fact—on each has been capable of conversion in this way into weight lifted a certain height in the course of the year. Reference will be made to these farms in more detail in the chapter on horse power; but I will now select three of them in illustration of the

assertion that a very large share of the horse labour of the farm may be done by steam power.

(1.) On a farm of 675 acres, occupied by Mr. Melvin, at Bonington, near Ratho, in Mid-Lothian, the whole horse labour of cultivation and carriage being converted, as I have already said, into weight, amounts to upwards of 100,000 cwt. pulled, *i.e.* lifted, one mile per annum. Of this the ploughing and scarifying alone amount to 27,000 cwts., or more than one quarter; the harrowing, rolling, and drill cultivation amount to upwards of 20,000 cwts., and the carriage of dung and crops and produce amounts to 60,000 cwts. lifted one mile. The carriage is here an enormous proportion—more than one-half of the whole horse labour of the farm, and much beyond its average amount in ordinary experience; but still even here one-quarter of the horse labour goes in mere ploughing, which can all be done by steam power, and *so* done as that an eight-horse power engine shall displace more than eight horses, and do their work much more effectually.

(2.) Again, on a farm of fen-land of 790 acres, occupied by Mr. Aitken, near Spalding, Lincolnshire, where the horse labour of the farm is nearly the same as in the last instance, or equal to 100,000 cwts. lifted one mile per annum, the carriage does not exceed much more than one-quarter of the whole, while the ploughing is nearly 40,000 cwts., four-tenths of the whole labour, and the harrowing and rolling about 35,000 cwts. per annum.

(3.) On Lord Ducie's farm, 260 acres, at Whitfield, Gloucestershire, the horse labour amounted to 37,600 cwts. lifted one mile per annum, and of this, 12,000, one third, was carriage; nearly 15,000, or four-tenths, was ploughing and cultivating; and the remainder harrowing, rolling, and drill culture. This seems to be a pretty ordinary division of the labour, and if it applies generally to arable land, it would appear that though farm carriage and all the lighter work of harrowing, and drilling, and rolling continue to be done by horses, there are still four-tenths of the horse labour of the farm which may be done by steam. It appears, then, that on arable land two-fifths of the horse labour of the farm can be handed over to a power which is capable of a very much larger duty at the same expense.

And there is a special advantage connected with the substitution of the cheaper power for that of horses; viz., that the horse labour thus displaced is taken from the most laborious periods of the year—those of spring and autumn cultivation. On examining

the horse labour of a farm of 240 acres of arable land under the alternate husbandry, it will be found that it does not much exceed 500 days of a pair of horses in the year, and that the need for it is distributed among the months extremely unevenly. Not more than thirty-five days of a team per month are wanted in December, January, and February; about forty-five days a month are wanted in March, April, May, and June; about fifteen days are wanted in July; about sixty in August, and ninety in September, and fifty-five in October and November. August and September stand highest, and as there are not generally more than twenty-four working days in each of these two months, there must be a provision of at least three and a half pair of horses all the year, in order that the work of August and September may be done. Now, the two-fifths of the horse labour, which is proper for steam power, if so accomplished, will not merely displace two-fifths of these seven horses through the year; for the ploughing and cultivating which are to be done by steam, constitute not two-fifths, but more than half of the labour of the encumbered months of March, April, and May, and August, September, and October; and if this be done by steam, the quantity of farm labour left will amount to little more than thirty-five days' work during each month of the year, which two pairs of horses will more than easily accomplish.

I believe then that by steam power, as applied to the more regular operations of cultivation, at least three out of every seven horses on arable land may be dispensed with all the year, and their work may be done for less than the cost of these horses during the three or four months when alone they are really needed on the land. And there can be but little doubt that this first class of operations upon the farm, which includes the ploughing and turning of the soil, will ultimately be taken by steam power out of the field of horse labour, just as threshing, and cutting, and grinding have been taken by it out of the field of hand labour.

To the second division of farm work I shall refer but very shortly. It includes such cases of ploughing and cultivation as are taken by rocky subsoil and crooked hedgerows out of the scope of the steam-driven plough; it also includes the lighter class of horse work, such as harrowing and horse hoeing, which, however, might very well be done by steam; and it more especially includes the work of carriage, which, considering the scattered position of the produce to be collected, and the crooked roads along which it must be drawn, I see no probability, so long

as these remain, of getting done except by horse power and manual labour in the usual way.

The third class of operations includes the lighter work of the farm, and attendance upon living things, requiring skill and thought as well as labour. The planting of a seed equidistantly upon the land may be done by machinery, but the culture of the young plant, much of the hoeing of the land immediately around it, and its treatment during growth according to its condition must be left to the hand. When ripe it may be harvested by horse-drawn implements—our corn crops are reaped, our potatoes may be dug, and roots are cut from the ground by horse-drawn machines—they must, however, be gathered into bundles or to heaps, and ultimately removed by the help of manual labour. When stored they are threshed, and ground, and cut, and steamed by steam-driven engines, but they must be administered as food by manual labour. Leaving the vegetable, which even when living may be treated to some extent by machinery, and when no longer growing becomes at once the subject of steam-driven processes, we come to the treatment of the animal which it feeds, and here we leave altogether the region of machinery actuated by steam, and are confined to the hand directed by intelligence.

Is it not a remarkable thing, however, that agriculture, which was once wholly the work of men's hands, but which has long since given up the tillage of the soil, and the carriage of the manure, and the sowing of the seed, and three-fourths of the hoeing of the crops to be accomplished by the horse—which has latterly given up the threshing of the grain and the cutting of its straw to be effected by steam power—which is rapidly abandoning the work of reaping to the former, and of cultivation to the latter, should nevertheless require more labourers than ever?

The explanation lies in this: that agriculture is more and more becoming the work of intelligence and skill as well as power: those parts of its processes, where intelligence and skill are wanted are becoming a larger portion of the whole. Cultivation is more perfectly performed, and over a greater extent of land; the crops cultivated are more laborious and more productive; the stock consuming them is proportionably larger and needs proportional attendance. Probably each acre cultivated in 1768 employed more manual labour in its cultivation then than each acre cultivated now; but how many more acres are there under cultivation now than then? Each bushel of wheat grown half a century ago involved so much more labour then that 8s. was the lowest price at which it could be grown with profit; but how

many more bushels per acre does land upon an average yield at present? Each pound of beef and mutton cost more in wages thirty years ago than now; but we have a double and triple store of food for stock, we have two crops of fattened sheep and cattle where formerly we had one, and each supplies a double quantity of meat.

But whatever the explanation be, the fact is certain, that the use of steam power on a farm is part of that system which employs most labourers in agriculture. This is indeed sufficiently illustrated by the table given on page 11, and further reference to it will be made in the section on hand labour.

8. The Cost of Steam Power per Horse Power per Hour.—In order to a comparison of horse power with that of steam, it is necessary to know what each costs for a given amount of force per hour. Steam power, when provided by the most economical furnace, boiler, and engine, as in Cornwall where fuel is very costly, is extremely cheap.

The Appold pump, at Whittlesea Mere, drains upwards of 500 acres of land at a cost of about £150, including coals, repairs of engine, engineman's wages, oil, &c. The quantity of water raised is 16,000 gallons, lifted six feet high per minute. The engine works about three days a week, and runs four or five hours at a time. According to this statement, the cost of the operation is about 4s. an hour; and the work done is equal to 960,000 lbs., or thirty times 33,000 lbs., raised one foot high per minute. This puts the cost of a horse power produced by steam equal to about 1½d. an hour, even under the unfavourable condition of an irregular employment of the engine, with the constant payment of the engineer; and of course it is much less than this in the case of the large and constantly working fixed pumping engines of our mines and waterworks.

The cost of the more ordinary agricultural engine must be gathered rather from ordinary experience than from the records of "racing" trials at an agricultural show; and I shall not be far wrong in putting the daily expenditure on an eight-horse agricultural locomotive engine as follows:—

Coals, 6 cwt. say	6s.
Water carting	4s.
Oil, &c.	1s.
Engineer's wages	4s.
Interest, and tear and wear, say 15 per cent. on £250 divided over fifty-two days, about	15s.
	30s.

Or 3s. an hour, corresponding to 4½d. per horse power per hour.

On a six-horse power fixed engine, costing about £250, which for many years was worked on a farm under my superintendence, the cost of "tear and wear" being then much less than in the case of the locomotive, the daily expenses stood as follows:—

	s.	d.
Coal, 6 cwt.	6	0
Oil, &c.	1	0
Engineer (a farm labourer)	2	6
Interest, &c., 10 per cent. divided over fifty days ...	10	0
	19	6

Or barely 2s. an hour; and therefore about 4d. per horse per hour. Another ten-horse power fixed agricultural engine known to me costs daily:—

	s.	d.
Coals, 8 cwt.	8	0
Oil, &c.	1	0
Engineer (a farm labourer)	2	6
Interest, &c. 10 per cent. on £400, divided over 100 days	8	0
In all	19	6

Which is about 2s. a day, or not 2½d. per horse per hour. It is plain that these amounts will diminish in proportion as the actual horse power got out of the engines exceeds the nominal horse power to which these estimates refer, and also in proportion as the engine is kept constantly employed, so that the annual interest of capital invested in it should come to be divided over a greater number of days. It seems also plain enough that, other things being equal, under ordinary circumstances the fixed engine must be a cheaper source of power than the locomotive, owing to the large share which repairs of tear and wear must have in its cost.

The relative merits of the two were discussed some years ago at the London Farmers' Club, when Mr. Allan Ransome, of the well-known firm at Ipswich, recommended, as the engine most applicable to agricultural purposes, for powers up to six or eight horses, that known as the horizontal engine, with the Cornish boiler, if to be used as a fixed engine, and with the multitubular boiler on wheels, if to be used as a portable engine. And on the question of preference between fixed and portable engines he

referred on the part of the former to the greater cheapness, durability, and the less liability to stoppage for repairs, less annual cost, and less attention required to make it work to advantage; and, on the part of the latter, to the facts that the crops might often be threshed directly from the stack, and the expense of removing into the barn avoided, and that as on most farms there could scarcely be found full employment for a steam engine, the use of the portable engine might be shared by two or three others. The general tendency of subsequent speakers on that occasion was to recommend fixed engines. But the history of the past fifteen years has completely upset the anticipations of these speakers, and the portable engine may be now pronounced the almost invariable form of agricultural steam power. The new use found for it in the cultivation of the land has arisen during this time, and it more than ever justifies the conclusion that these portable engines are of the greatest agricultural benefit.

A direct comparison of the cost of steam power with that of horses in the work of cultivation, will be attempted in the chapter on horse power; and the cost of different processes, whether of cultivation or otherwise, into which steam power enters, will be estimated in a number of instances, in the fifth section of this book.

9. Quantity of Steam Power now used in Agriculture.—What the total quantity of steam power now in agricultural use in this country may be we have no means of ascertaining. Of its annual increase, however, we can more easily judge.

From returns by all the leading manufacturers of steam engines for agricultural purposes, given to me some years ago, it appeared that 10,000 horse power was then being annually added in steam alone to the forces used in agriculture. Messrs. Clayton and Shuttleworth of Lincoln, Garrett of Saxmundham, Hornsby of Grantham, Ransome of Ipswich, and Tuxford of Boston, were then indeed alone furnishing that quantity of horse power annually to the farmer. Messrs. Tuxford, among the first to start the locomotive agricultural steam engine, inform me that for the earliest suggestion of it they were indebted to Mr. John Morton, of Gloucestershire, then agent to the late Earl of Ducie, who nearly thirty years ago recommended them to put their engines upon wheels, thus foreseeing the fitness of these powers made locomotive to the circumstances of English agriculture. Messrs. Ransome of Ipswich were, I believe, the earliest to receive the

commendations and the prizes of the Agricultural Society of England for their engines; and now the leading manufacturers of them, Messrs. Clayton of Lincoln, send out ten of them each week, or 4,000 horse power per annum.

This large force of course is for the most part employed at the homestead in threshing, grinding, cutting &c.; but it is also employed on many farms in cultivation in the field. Some hundreds of sets of steam-cultivating tackle are now at work, and tens of thousands of acres are annually stirred or ploughed in this country by steam power; and it may be considered certain that the use of steam power for this purpose will now rapidly increase. It is the more powerful of our locomotive engines which are available for field work; but concurrently with the extension of the manufacture in this direction, a large number are now being made of two and three horse power for doing the less laborious work of cutting and grinding cattle-food, &c. Mr. Nicholson, of Newark, who has, I believe, the credit of foreseeing the fitness of these small engines to our gradually altering agricultural circumstances, informs me that he first showed one at the Lincoln meeting of the Agricultural Society (1854), while at Warwick, five years later, no fewer than thirty such engines were exhibited by different makers; and they now form a considerable section of every exhibition of agricultural steam-engines. And it may be repeated, that of the whole agricultural steam power now annually added to the forces used in agriculture by the engines turned out from the yards of the manufacturers, but a small percentage is derived from fixed engines. The profitableness of locomotives let for hire along with portable threshing machines, creates a greater demand for steam power in that form than is presented by those landowners who give orders for fixed barn machinery in newly erected homesteads.

10. Economical Management of the Steam Engine.—Under this head I propose merely to quote the instructions given by Messrs. Ransome, in the nineteenth volume of the *Agricultural Society's Journal.* They relate to the portable engine only, but are essentially applicable to both kinds. They are given, very much abridged, in the following paragraphs :—

(1.) Place the engine as level as possible, and in such a position that the dust caused by threshing may not be blown upon it.

(2.) Procure water as clean as possible for the use of the engine. Fill the boiler till it appears about half way up the glass gauge tube.

(3.) The water-guage cocks should always be tried before the

fire is lighted, to ascertain that there is no obstruction in the passages which would prevent the water finding its proper level in the glass tube; the bottom one should discharge water only, and the top one steam; the level of the water in the boiler being somewhere between the two gauge-cocks.

(4.) The fire-bars must be well cleaned from dirt and clinkers before the fire is laid; a few dry shavings and a small quantity of firewood should then be spread over the bars, and some small coal scattered over them; a light may then be applied to the shavings from beneath the grate bars, and the fire will soon burn briskly; coal may then be put on in small quantities at a time, the fire-bars being kept covered to a depth not exceeding three inches; the fire must be clear, but the bars must not be allowed to become bare of coal in places, for the cold air will then pass through the tubes, and check the formation of steam; all wet straw and damp wood should be avoided for lighting the fire. As soon as the fire is lighted, a few pails of water should be poured into the ash-pan.

The fire as it burns up should be kept thin and bright; the coal must never be heaped up against the tubes; too much coal should not be thrown on at a time, or it will tend to delay the production of steam. Wood should never be used as a fuel when the engine is at work, on account of the great quantity of ignited pieces blown out of the top of the tunnel by the steam blast; the foolish and dangerous practice of carrying hot coals in shovels from the farm-house to the engine in the stack-yard for the purpose of lighting the fire should never be allowed.

(5.) If the coal is bad, or of a kind which emits a large quantity of smoke, the tubes should be well brushed out during the dinner hour; this can easily be done without dropping the fire, by allowing it to burn low, and raking it into one corner of the grate.

(6.) As soon as the water begins to boil, the safety-valve should be opened by hand and examined, to make sure that it is not obstructed in any way; the spring-balance may then be screwed down to about 10 lbs., and when the steam blows off at that point, it may be gradually screwed down to 45 or 50 lbs. as the steam rises. The spring-balance should on no account be left always screwed down to the full pressure when the engine is not at work, and the steam not up.

(7.) Before starting, put a little oil into the cylinder, through the cock provided for the purpose, and move the engine round by

hand, by means of the fly-wheel, to ascertain that it is all in working condition; all the oil-cups must be filled up and the syphon-wicks examined, to make sure of their being in good condition. A little oil should be put upon the guide-bars themselves, as well as into the oil-cups attached to them; the pump-plunger, and all the eccentrics, must also be oiled. Neatsfoot or sperm-oil should be used; but if this cannot be procured, olive-oil will answer the purpose.

(8.) The piston should be placed at about the half-stroke, and the regulator-valve opened gradually, the two relief-cocks on the cylinder being previously opened; after the engine has made a few revolutions these cocks may be shut, and the regulator-valve set full open, so that the speed of the engine may be controlled by the governors. The feed-pump should be tried as soon as the engine is in motion, to ascertain that it is in working condition, before the water has had time to diminish.

(9.) It is desirable to have a constant supply of water always going into the boiler from the feed-pump; a little experience will soon point out to the engineman how far the cock requires to be open to enable him to do this.

(10.) There should never be less than two inches of water visible in the glass guage-tube when the engine is at work; if, by accident or neglect, the water should become so low as only to show about half an inch in the glass tube, the fire should instantly be dropped, by lifting the fire-bars from their places by means of the tools furnished for the purpose, the burning coals will fall into the water in the ash-pan, and be extinguished; water should never be thrown into the fire-box to put out the fire, it is apt to scald those who do so, and to injure the fire-box; the fire must on no account be again lighted until the boiler has been filled up.

(11.) The bearings and guide-bars should be carefully examined from time to time to see that they are properly supplied with oil from the lubricators attached to them; it is a good plan to put a little extra oil upon the guide-bars, in addition to filling the lubricators upon them. Whenever the engine is stopped, all the bearings should be felt, to make sure that they have not heated; if there be any disposition to heat, the bearings having such a tendency may be loosened a little, but they must not be too slack.

(12.) When the day's work is over, and the engine is going to be moved to another place, the water should be run out of the boiler when the steam is quite down; the practice of blowing all

the water out of the boiler directly the fire is dropped is a very bad one, for the sudden contraction of the tubes caused by the rapid cooling makes them leaky.

(13.) After the day's work is done the engine should be well rubbed over with cotton waste, and all dust and grit should be removed, also all superfluous oil which may have accumulated during working; the chimney should be lowered down, and the engine be covered over with the tarpauling furnished for that purpose: the engine should always be carefully covered up when travelling, to prevent the working parts from becoming injured by dust or mud.

(14.) The boiler must be well washed out and cleansed after about twelve or fourteen days' working; to do this the brass plugs and mud-doors round the bottom of the outside shell of the fire-box must be taken out; water must be poured freely into the boiler through the opening where water is poured in, the mud and scales being at the same time loosened and pulled out with a small iron rod, the end of which should be made like a hoe; at the same time the plug beneath the tubes in the smoke-box should be taken out, and the man-hole cover be lifted off; a long rod being pushed backwards and forwards through the hole under the tubes, so as to loosen the dirt and sediment. Water should be poured into the man-hole plentifully, so as to wash out all that may be collected in the boiler through the various mud-holes, which should all be open during this operation.

11. Water Power for Agricultural Purposes.—Let us turn now to another power which, when available, is necessarily cheaper than any other, and which is especially adapted to such operations as need an hour or two almost daily for their performance in almost every homestead. I propose, in elucidation of this subject, to give the reports of two gentlemen who have with considerable difficulty obtained water-power for such use upon their premises. (1.) My first report is from J. T. Harrison, Esq., late of Frocester Court, near Stonehouse, Gloucestershire. He says:—

"There are some operations on a farm, such as chaff-cutting and pulping, for which water power is much more convenient than steam or horses. They have to be performed daily, and it is therefore of immense advantage to have an inexpensive power at command to perform these operations. Besides chaff-cutting and pulping, oat crushing for the horses, corn grinding for the pigs and cattle, threshing, winnowing, and apple grinding in the

cider districts, may be done at a less cost by water than by steam, where sufficient power can be obtained; but steam can be applied for these latter operations very usefully, as the work may be continued steadily all day, which is not the case with daily operations of short continuance. We find great advantage in very wet weather in being able to turn all hands into the barn to thresh, as it would be difficult then to employ them otherwise. Ours is, however, an exceptional case, in consequence of our immense barns enabling us to stow away a large proportion of the corn grown on the farm.

"At the present time we are cutting 18 cwts. of chaff and pulping 3 tons 8 cwts. of roots daily, and occasionally bruising oats and grinding corn by water-power.

"To accomplish this work we are obliged to be careful and not waste any water. The quantity of water flowing into the reservoir per diem is about 500 cubic feet per hour, or at the rate of 84,000 cubic feet per week. From the level of the water in the reservoir to that of our turbine there is a fall of about twenty-two feet.

"The quantity of water driving the water-wheel whilst we are

"Chaff-cutting is	92	cubic feet	per minute.
Pulping roots	103	,,	,,
Chaff-cutting and pulping together	114	,,	,,

"We can cut $\frac{1}{4}$-cwt. of chaff per minute, and pulp thirty cwts. of swedes in twenty-seven minutes, or thirty cwts. of mangolds in twenty minutes.

"Thus we find it takes to cut 18 cwts. of chaff, say...	$1\frac{1}{4}$ hours.
And to pulp 3 tons 8 cwts. of roots	1
Total, $2\frac{1}{4}$ hours' work for the food daily consumed.	

"And in doing this it will be found on calculation that we use about 86,000 cubic feet of water per week, with the twenty-two feet fall, which is, I believe, not far from the average truth; though probably at the beginning of the week less water is used to do the work, as it then stands somewhat higher in the reservoir.

"The following information may be useful to those who have a pretty steady supply of water, if only in the winter season, when for chaff-cutting and pulping its application would be very useful.

"The first thing to ascertain is the quantity of water at command. For this purpose take a piece of board of sufficient length to cross the stream, and, say eighteen inches wide. Cut a piece

out of one side of it, say three inches wide and nine inches deep, and make the edges smooth for the water to pass freely (these dimensions must, however, depend upon the quantity of water, and the opening must be widened so as to permit all the water without waste to pass through it). Fix the board across the stream, and by puddling the bottom and sides force all the water to pass through the aperture. When the water has risen as high as it can, mark exactly the height in feet at which it stands above the bottom of the opening; this dimension in the following rule is represented by H, and the width of the aperture in feet by W.

"The quantity of water passing in cubic feet per minute is equal to $200 \times H \times W \times \sqrt{H}$. For example, the aperture used to ascertain the quantity of water passing from the water-wheel was 1·17 feet wide, and the height at which the water stood when cutting chaff was ·54 feet. Then $200 \times 1{\cdot}17 \times {\cdot}54 \times \sqrt{{\cdot}54}$ (or ·73) gives 92 cubic feet as the quantity passing every minute.

"Having ascertained the quantity of water which is available, the next point is to find out, by means of a spirit-level, what fall you can obtain. You have thus decided the elements of the power at your command, namely, the quantity of water per minute and its fall. But as the water is running constantly, and you require it only for a short time each day, you may, by forming a reservoir for the water, bring a force to bear for a short time considerably larger than were the water used constantly. Our reservoir (part of the old moat enlarged) holds 300,000 cubic feet or more.

"The reservoir should be as close as possible to the water-wheel, as it adds considerably to the first cost when the water has to be conveyed far in pipes (in our case, where the reservoir is 700 feet from the wheel, the twelve-inch cast-iron pipes cost fully £100 extra), and there is besides a great loss of power from friction on the sides of the pipes.

"For general purposes the wheel we use answers admirably; it is a turbine, made by Mr. Whitelaw, of Glasgow (Messrs. Randolph, Elder and Co., Glasgow, manufacture similar water-wheels), and has not cost one shilling for repairs during the last eight or nine years, and is now as good as ever. This description of water-wheel is preferable to others for farm purposes, on account of the great velocity with which it works; ours makes 200 revolutions a minute, so that there is no occasion for multiplying cog-wheels even for threshing, as the requisite speed is obtained by a large wheel driving the strap, as in the steam threshing machines. The

turbine has, moreover, the advantage of producing a greater effect from a given quantity of water falling through a given height than any other description of wheel.

"Having determined of what horse power it is desirable to have the water-wheel—say not less than five-horse power if it be desired to thresh with it, or three-horse power if it is only to be used for chaff-cutting and pulping; and having ascertained the fall that can be obtained for the water, the following rule will give the quantity of water that is required per minute to drive the wheel.

$$\text{"The quantity of water per minute in cubic feet} = \frac{696 \cdot 73 \times \text{number of horse-power.}}{\text{Fall of water.}}$$

"Our turbine is fitted with regulators, as in the steam engines, so that when the work is light, and the velocity increases, the balls fly out, and by means of levers lessen the aperture for the escape of the water.

"Calculating from the data given above, and making allowance for the diminution of power in consequence of the friction of the water in passing through the pipe, and taking the fall at twenty-two feet, about which it was when we ascertained the quantity of water used, we have—

	Cubic feet per minute.	
"The number of horse-power used in chaff-cutting ...	$= \frac{93 \times 22 \text{ feet fall}}{696 \cdot 73}$	$= 2 \cdot 9$ horses.
,, in pulping		$= 3 \cdot 25$,,
,, both at once		$= 3 \cdot 6$,,

"The maximum discharge of water which occurs when we are threshing with a head of twenty-five feet, gives an effective power of about four and a half horses.

"For further particulars your readers may be referred to the 'Engineer and Machinists' Assistant,' published by Messrs. Blackie and Son, Glasgow, in 1846, which gives very full and excellent information on the subject of water-wheels of every description."

(2.) The following interesting report is added on the same subject from P. MacLagan, Esq., M.P., of Pumpherstone, West Lothian. I give the account in full detail as illustrating the way in which the difficulties of obtaining water power have been overcome.

Mr. MacLagan says :—"I will first describe the circumstances which in my case make water power suitable and economical, and the mode in which these circumstances have been turned to

account. There is a natural and uniform fall of about 130 feet from the highest to the lowest part of my farm. My steading is situated about the middle of the declivity, that is, about sixty-five feet from the highest point. The principal drainage of the district is from west to east, so that the drainage-water of some of the lands to the west of mine, flows through my farm in several ditches. Fortunately, two of these ditches were on the highest of my grounds, about ten years ago an unimproved moor, the centre of which was very level, so that by throwing up a low dam the water was intercepted in its course, and a pond was formed of considerable extent. The waste water, after the pond was full, was made to flow to the south towards my steading, and a sluice was put into the south dam to let off the water in the same direction. About 200 yards below this was an old quarry-hole, near which was another ditch conveying the water from the west. This water was also dammed back, and filled the quarry-hole, forming a second pond of considerable size, the waste water from which flowed south also down a hollow, and a sluice was placed in the dam. About 200 yards north of the steading, the form of the hollow was such that by throwing up another dam at a trifling expense, there was obtained a third pond, in which also a sluice was placed.

"Such was the state of matters when I came into the possession and occupancy of the farm about thirteen years ago. As it was my intention to go on vigorously with improvements, calculating upon a considerable increase of produce, I felt convinced that, as there was not a constant supply of water, for which my whole dependence was on the clouds, I should be put to inconvenience in the threshing of my crop. Therefore, whenever my men and horses were not busy in summer after all the crops were sown, I commenced to deepen the ponds, and enlarge them. I took out two or three thousand cart loads of water-fed soil and vegetable matter from them, with which lime was mixed, forming a valuable compost which more than paid for the labour. Some of the clay bottom was also taken out, and carted on to the banks to strengthen them, and raise them in height. As the moor round the upper pond was planted, and it was necessary to have roads by which the trees might be carted out when they were cut down at a future time, the dams of this pond were made wide enough to be used for cart roads when required. The supply of water has also been largely increased, by cutting feeder drains, which convey to the lower ponds a great part of the drainage-water of the lands on the

higher levels, that used to flow in a different direction before the fields were drained. The ponds or reservoirs now extend to about four acres, and are capable of containing water sufficient to thresh from 150 to 200 qrs. of wheat.

"I am sorry that I cannot give you from my own experience, as you request, a statement of the relative cost of water, steam, and horse power. A few years ago, however, when making inquiry into the expense of threshing by steam, I obtained from some neighbours a few particulars which I will now make use of in a comparative statement of water and steam power. I have selected two steam engines for the comparison; the one was old, and belonged to a tenant whose lease was near its termination, so that in all likelihood at the commencement of a new lease he would have made a thorough change in his machinery; the other belonged to a tenant who had just entered on a new lease, and had erected a new steam engine and threshing machine, the details of the average working of which, during the first winter, are given below. The first engine and mill cost probably about £160, the second cost £190, and my reservoirs, water-wheel, and threshing-mill were valued over to me at £145. As this is a comparative statement between steam and water power, it is not necessary to enter into any details excepting those in which they differ, such as the consumption of coal, and the time of a man to attend on the steam engine while it is working, which is not required in a water-mill. I believe too that there ought to be a larger sum allowed for the annual tear and wear of the steam engine than for that of the water-mill, but I have not taken this into account at present.

Cylinder.	Boiler.	Quantity threshed of Wheat per hour.	Coals consumed per hour.	Cost of Coals consumed per hour, including Carriage.	Attendance on Engine per hour.	Total for Coals and Attendance per hour.	Cost of Coals and Attendance per quarter.
			No. 1 Engine.				
9 in.	$14\frac{1}{2}$ ft. long.	2 qrs.	2 cwts.	1s.	3d.	1s. 3d.	$7\frac{1}{2}$d.
			No. 2 Engine.				
11 ,,	18 ft. by 3·10	$4\frac{1}{2}$,,	$1\frac{1}{4}$,,	$7\frac{1}{2}$d.	3d.	0s. $10\frac{1}{2}$d.	$2\frac{1}{4}$d.
							2) $9\frac{3}{4}$d.
		Average of cost of coals and attendance per qr. of wheat .					$4\frac{7}{8}$d.
			Water Mill.				
Overshot wheel 18 ft. in diameter.		2 qrs.	,,	,,	,,	,,	0d.

According to the above, then, it costs 4¾d. per qr. more to thresh by steam than by water. This is no doubt too high, owing to the comparative inefficiency of No. 1 Engine, but a common calculation for fuel in this district is 2d. per qr. when the carriage of coals is included, to which we must add ¾d. or 1d. per qr. for attendance on engine. It must not be supposed that these threshing mills could not do more work than what we have stated above. The figures indicate the average rate of work performed by them with the ordinary force of labourers on the farm."

12. Wind-power for Agricultural Purposes.—On this I must merely say that more windmills, during the past twenty years, have been destroyed than have been erected. They have been displaced by steam or water power—the certainty of these being more than a compensation for their greater cost. It is, however, proper to add, that a wind engine manufactured by Mr. Peill, of New Park Street, Southwark, which possesses self-regulating appliances, so that, once set, it needs no superintendence beyond a weekly oiling of its bearings, is coming into pretty frequent use for pumping water, for grinding corn, crushing oats, cutting chaff, and driving other farm machinery, where a constant power is not required. It costs about £50 per nominal horse-power, and numerous testimonies are being received of its fitness for work of the kind just named. For instance, Mr. Christy, of Boynton Hall, near Chelmsford, thus answers a correspondent of the *Agricultural Gazette*:—

"I have one of Mr. Peill's wind engines of ¾ horse power, with one of Messrs. Warners' pumps attached, that has been at work about nine months. It is erected nearly half a mile from the premises, and pumps the water from a spring to a height of seventy feet: supplying the house and farmyards, and filling a large pond that has been dry for years. It requires very little wind, and (owing to the sails being self-adjusting) no attention save oiling once a week. If placed near the farmstead, it might be used to drive a chaff engine, &c., when not required for pumping."

III. HORSE POWER.

The results of a number of inquiries on this subject, which had been addressed during the autumn of 1858 to correspondents in all parts of the island, were embodied by me in a paper on the cost of Horse Power, which was published in the 19th volume of the *English Agricultural Society's Journal*. They are repeated

here in somewhat different order, so as to bring out more perfectly what information they convey on the economical management of horses.

The following chapter, however, is essentially the same as has been already published on the subject in the *Journal of the Royal Agricultural Society of England.*

13. The Food of the Horse.—The following describes the practice and experience of the late Robert Baker of Writtle on this subject, as related by him in one of the latest of the many contributions to agricultural literature made during his useful professional life. He writes as follows :—

(1.) "My present treatment of horses from Michaelmas to April is as follows :—Their daily food consists of—

"Clover hay	10 lbs.	cut into chaff.
Straw	20 lbs.	
Good oats	10 lbs.	
	40 lbs. per diem.	

During the seed times (about five weeks each) 4 or 5 lbs. of good old split beans additional are given per diem, and from the end of November till the middle of February the oats are in part taken off, according to circumstances,—reduced to 6 lbs. per diem, the full quantity of 10 lbs. being given always whilst at plough-work.

"During the spring months, say from the middle of April, my horses have early rye, mown green, and cut up with the hay and straw, increasing the former and diminishing the two latter weekly, until by the middle of May rye alone is used cut as before; and the horses will continue to eat it when so managed till the middle of June, when the rye has come fully into ear, and at that period they get in better condition than at any other portion of the year. From the time that the rye ceases, vetches with rye are substituted for about two weeks, and then vetches, or red clover mown, or lucerne, are substituted, but not always cut up, as before, into chaff. The horses are kept in the yard so long as food can be procured, which is sometimes the case until the second math of red clover is fit for mowing, which is combined with hay and straw, and cut up daily for the teams *ad libitum.* If, however, the math is abundant, it is given alone, *i.e.* with only the addition of late spring tares, if the season is suitable; but this depends entirely upon the season, as in cases of drought the late tares do not succeed in the eastern counties.

"My horses, I calculate, eat 1 peck of good sound oats daily, or say 2 bushels per week for eight months in the year; and

when eating green food in the summer months, say 1 bushel each per week—rather less than more; but upon heavy-land farms another bushel of oats, or beans and oats, is given for six weeks in the autumn and spring seed-times per week. A horse will require dry food at least seven months in the year, and, eating about 21 lbs. per diem, will during that period eat about 35 cwts. of hay per annum; and he will eat in addition about 1 cwt. of green food per diem during the remainder of the year, say 150 days, or from 7 to 7½ tons for that time. The best of the oat straw, and pea and bean straw, may be reckoned to supply food for two months of the year.

"The cost of horse-keep in Essex upon the above principle of management will for each day be about the same as that of a farm-labourer, but for all calculations a further sum must be added to meet the wear and tear of the horse and for shoeing, to which the farmer is not liable as regards manual labour. The sum of 3s. per horse per day during that portion of the year comprised from Lady-day to Michaelmas is assumed by valuers as the fair sum to be paid for each horse for each working day when at plough, and 2s. 6d. when at other work, per diem. An experiment was once made by myself as to the annual consumption of food by a farm horse, and the conclusion arrived at was as follows:—

	£	s.	d.
"2 tons of hay at feeding value	6	0	0
7 tons of green food at 20s.	7	0	0
9 qrs. oats at 24s	10	16	0
1 qr. of beans at	1	16	0
Add straw and chaff	1	10	0
Cost of keep for one year	27	2	0

"My horses are fed in open yards, with sheds, each parted off for a team of four horses. These, upon returning from labour, are unharnessed and fed in the stable until about six o'clock, when they are put into the yard with a sufficiency of cut chaff for the night. At from four to five o'clock in the morning they are brought into the stable, and fed with the corn and chaff until the time of going out to work—in summer half-past five o'clock, in autumn half-past six o'clock, and in winter rather later. They work until ten o'clock, and invariably come home and are fed and watered, one hour being allowed. They then return and work till three o'clock, an acre of ploughing being performed. This mode of management appears congenial to the health of the horses, as we rarely have any sickness among the teams, and I have not lost

more than two horses during the last six years from upwards of twenty constantly worked."

Mr. Baker's practice and experience are given at full length in the foregoing paragraphs; but in the following account of the stable practice upon other farms, the facts are stated in as condensed a form as possible, so as to embrace the results of an extensive inquiry within the compass of a few pages.

(2.) The following tables give the daily ration adopted in the farm stable during spring, summer, autumn, and winter respectively, by those whose names are in every case attached. In successive columns I have put, first, the number of the case; secondly, the authority on which it is given; thirdly, the weight consumed per week of hay, oats, beans, roots, clover, and straw by a horse; and lastly, the calculated weekly cost of so maintaining it. This cost is calculated at the rates of 3s. a cwt. for hay, 3s. a bushel for oats, 5s. a bushel for beans, 4d. a cwt. for turnips or mangold-wurzel, 6d. a cwt. for carrots and clover, and without charge for straw. Where an *asterisk* (*) is attached to any item it is to be understood that the corn has been bruised or ground, or the hay or straw has been cut into chaff; where a *dagger* (†) is appended, the article so marked has been boiled or steamed; a mark of interrogation (?) indicates that the result so marked is uncertain, owing to some indefiniteness in the account given. The prices adopted in calculating the cost of food are the market prices of the *grain* consumed; and in the cases of the *hay* and *green food*, the value which it is supposed they might produce if given to other kinds of live stock on the farm.

There are no fewer than 115 cases named in the tables. If any of the methods of feeding described should seem whimsical, the excuse which must be taken for their appearance is, that not one of them is merely fanciful—not one of them is a mere scheme or a proposal—every one is actually adopted and in use on farms, many of them in whole districts in this country.

There is considerable difficulty in estimating the cost of pasturage, cut clover, and other food supplied *ad libitum.* It will be found in the money column of the following table, which specifies the calculated cost per week of food alone for each horse in the stable, that 5s. a week has been charged for pasturage alone, 6d. a cwt. for cut clover carried to the stable, and from 1s. 6d. to 3s. a week for night pasturage, according to the quantity of other food supplied. When that is tolerably abundant, and clover is supplied *ad libitum*, it is supposed that each horse will eat one cwt. a day.

No.	Name and Address.	Hay.	Oats.	Beans.	Roots.	Clover.	Pasture.	Weekly Cost.
	THE SUMMER SEASON.	lbs.	lbs.	lbs.	lbs.	lbs.		s. d.
1	———	...	...	...	...	...	ad lib.	5 0
2	Professor Low—Elements of Agriculture ...	...	35	...	...	1,400	...	8 9
3	H. Stephens—Book of the Farm	...	...	...	...	ad lib.	Night.	7 6?
4	J. Gibson, Woolmet—Highland Soc., 1850	...	50	...	...	5s. 3d.	...	9 0
5	— Binnie, Seton, ,, ...	...	70	28	...	ad lib.	Night.	11 0?
6	,, ,, ...	...	50	...	...	ad lib.	Night.	8 0?
7	— Thomson, Hangingside ,, ...	...	84	...	...	ad lib.	...	9 6
8	— Barthropp, London Farmers' Club, 1853	...	20	80	...	2s.	...	9 9
9	,, ,, ...	...	...	48	...	3s.	...	6 9
10	J. Morton, Whitfield Farm, 1843	...	70	...	...	784	...	8 9
11	Mr. C., quoted at Gloucester Farmers' Club, 1843	...	80	...	...	5s.	...	11 0
1	W. Gater, Botley Farmers' Club	...	...	16	Bran. 2 bushels.	ad lib.	...	8 0?
13	W. C. Spooner, Ag. Journ., vol. ix., p. 274 ...	...	42	...	...	5s.	...	8 0
14	J. Twynam, Botley Farmers' Club	...	42	...	...	$2\frac{3}{4}$ rods.	...	5 9
15	T. Baldwin, Glasnevin	...	35	...	...	700	...	6 0
16	J. Coleman, Cirencester	...	42	...	...	ad lib.	...	6 6
17	J. Cobban, Whitfield	...	42*	...	...	ad lib.	Straw. ad lib. Night.	6 9?
18	E. W. Moore, Coleshill	...	63	32	...	ad lib.	Pasture. Night.	10 6?
19	,, ,, ...	...	63	...	...	ad lib.	Night.	8 0?
20	S. Rich, Didmarton, Gloucestershire ...	84*	$31\frac{1}{2}$	...	...	1s.	2 acres.	7 6?
21	F. Sowerby, Aylesby, N. Lincolnshire ...	...	...	28	...	...	ad lib.	6 0?
	THE AUTUMN SEASON.						Straw.	
22	Professor Low—Elements of Agriculture ...	140	70	...	...	...	...	9 0
23	,, ,,	140	50	...	Potatoes. 70	...	...	7 6?
24	W. Gater, Botley F. Club	168	63*	32*	...	...	...	12 0
25	W. C. Spooner, Agr. Soc. Journ., vol. ix., p. 274	112	84	24	...	...	...	11 0

26	T. Aitken, Spalding, Lincolnshire	...	$37\frac{1}{2}$	..	...	ad lib.	...	7	6?
27	" "	...	$37\frac{1}{2}$	35	...	ad lib.	...	10	0?
28	T. P. Dods, Hexham	...	105	...	...	ad lib.	...	10	6?
29	" "	ad lib.	105	...	...	...	...	10	6?
30	A. Ruston, Isle of Ely	ad lib. ½	84	10	Bran. ⅓ bushel.	...	Straw. ad lib. ½	9	0?
31	A. Simpson, Beauly, N.B.	168	70	14	...	...	24 lbs.	10	0
32	H. J. Wilson, Mansfield	...	$52\frac{1}{2}$	...	...	ad lib	Straw. ...	7	3?
33	" "	42	$87\frac{1}{2}$	...	Bran. 21 lbs.	...	ad lib.	9	0
	THE WINTER SEASON.								
34	Professor Low—Elements of Agriculture ...	...	70	...	...	...	Straw. ad lib.	5	3
35	" " ...	...	50	...	Potatoes. 70†	...	...	4	9
36	" " ...	56*	56*	...	56†	...	56*	6	6
37	H. Stephens—Book of the Farm	...	70	...	Turnips. 112	...	70	5	7
38	" "	112	35	...	112	...	...	6	0
39	" "	...	56	...	77†	Potatoes. ...	105*	4	6
40	J. Gibson, Woolmet—Highland Soc., 1850	...	84	...	217†	217†	112*	9	0
41	— Binnie, Seaton	...	70*	28*	243†	Barley. 42†	ad lib.	11	6
42	— Steedman, Boghall	...	70	...	500	Linseed. $3\frac{1}{2}$	ad lib.	7	6
43	— Thomson, Hangingside	...	84	14	336	Barley. 14	ad lib.	9	6
44	— Black, Dalkeith	112	84*	...	196†	...	...	10	0
45	— Barthropp—London Farmers' Club, 1853	112	21	80	224	...	...	11	8
46	" " ...	112	...	48	224	...	...	7	6
47	Mr. C., quoted by Mr. N., Gloucester F. Club	...	84	...	...	Carrots. 784	...	9	6
48	J. Morton, Whitfield Farm	...	126	...	...	350	ad lib.	10	9

No.	Name and Address.	Hay.	Oats.	Beans.	Roots.	Clover.	Pasture.	Weekly Cost.	
		lbs.	lbs.	lbs.	lbs.	lbs.		s.	d.
49	W. Cater, Botley Farmers' Club	...	...	32*		Pollard. 40	ad lib.	5	6
50	J. Twynam, ,, ...	112	63	16	...	...	...	8	9
51	— Trotter, Darlington F. Club, 1845 ...	ad lib.	84	64	...	...	...	14	0?
52	,, ,, ...	...	73	Cut Oat Sheaf.		...	110	5	3
53	W. C. Spooner, Agricultural Gazette, 1845 ...	28	63	16	112	...	28	7	0
54	H. Briggs, Overton, ,, ...	140	110	...	...	...	...	11	6
55	,, ,, ...	294	...	...	...	...	...	7	6
56	,, ,, ...	...	...	64*	...	Linseed. $3\frac{1}{2}$	140	6	6
57	Quoted by Bacon—Agriculture of Norfolk ...	56*	44	28*	...	...	...	7	0
58	,, ,, ...	75	42	21	...	...	...	6	8
59	,, ,, ...	75	...	64*	a few.	...	...	7	6
60	,, ,, ...	112	42	25	...	Bran. 16	...	9	6
61	,, ,, ...	112	84	...	...	...	ad lib.*	10	0
62	Bartliever Farm, Ag. Journ., vol. vi., p. 454	...	84	...	112	...	70*	7	0
63	,, ,, ...	112	42	...	112	...	...	7	0
64	R. Smith, Bath & W. of Eng Soc. Jour., vol. i.	147	$73\frac{1}{2}$	...	...	...	...	9	3
65	,, ,, ...	98	37	28	...	...	49*	8	0
66	,, ,, ...	70	...	56	...	Bran. 49	70*	9	6
67	,, ,, ...	140	56	...	49	...	...	8	3
68	,, ,, ...	70	...	...	56	Tail Corn. 49	70*	5	6
69	,, ,, ...	98	98	...	...	...	49	9	9
70	,, ,, ...	24*	37	...	...	Linseed. 14	140	5	3
71	,, ,, ...	84	44	49	...	Grains. 140	...	12	0
72	,, ,, ...	154	...	...	...	Grown Barley 84	...	9	0

73	R. Smith, Bath & W. of Eng. Soc. Jour., vol. i.	49	...	37	...	Linseed. 7	98	5	0
74	,, ,, ...	70	...	70	...	...	70*	7	3
75	,, ,, ...	49	...	35	Potatoes. 70	Grains. 42	49*	6	0
76	,, ,, ...	140	..	...	Turnips. 84	Tail Corn. 63	...	8	0
77	,, ,, ...	70	52	...	...	Oil-cake. 28	70*	8	3
78	,, ,, ...	77	37	21	280	...	...	7	6
79	,, ,, ...	...	73	...	780	...	112*	6	3
80	W. C. Spooner, Agr. Soc. Journ., vol. ix., p. 274	...	63	...	42	...	196	4	9
81	T. Aitken, Spalding, Lincolnshire	ad lib. ⅔	37½	35	...	...	ad lib. ⅓	9	0
82	G. W. Baker, Woburn, Bedfordshire ...	...	60*	20*	...	...	...	9	8
83	R. Baker, Writtle, Essex	70	42	...	...	...	140	5	0
84	,, ,, ...	70	73	...	...	...	140	7	3
85	J. Coleman, Cirencester	...	84	16	...	...	ad lib.	7	3
86	T. P. Dods, Hexham	...	95	...	56	...	ad lib.	8	0
87	T. Baldwin, Glasnevin	210	70*	...	Carrots or Bran. 49	42†	...	11	6?
88	J. Cobban, Whitfield	84*	60*	...	Linseed. 3½	...	ad lib.*	7	3
89	S. Druce, jun., Eynsham	112	52½	...	Swedes. 70	...	2 bushels.*	7	0
90	C. Howard, Biddenham	ad lib. ⅔	52½	17½	84	...	ad lib. ⅓*	8	6?
91	J. Laidlaw, Frampton-on-Severn	...	84	...	...	Carrots. 336	ad lib.	7	6
92	I. J. Mechi, Tiptree	49*	70*	...	M. wurzel. 210	...	ad lib.*	7	6
93	D. A. Milward, Waterford	35*	49*	...	Turnips. 280†	Gorse. 1464*	35*	7	0?
94	W. J. Pope, Bridport	2*	84	...	...	...	ad lib.	9	0?
95	S. Rich, Didmarton, Gloucestershire ...	168	63	...	...	Grains. 2 bushels.	ad lib.	10	8
96	A. S. Ruston, Isle of Ely	ad lib. ½	84	...	...	...	ad lib.*	8	0?

No.	Name and Address.	Hay.	Oats.	Beans.	Roots.	Clover.	Pasture.	Weekly Cost. s.	d.
		lbs.	lbs.	lbs.	lbs.	lbs.		s.	d.
97	H. E. Sadler, Lavant, Sussex	140	84	...	...	...	...	9	9
98	E. H. Sandford, Dover	56	42	...	...	Bran. 12	ad lib.	5	6
99	A. Simpson, Beauly, N.B.	...	49	7	105	Tail Corn. 21	ad lib.*	5	6
100	H. J. Wilson, Mansfield	42	52½	...	...	Bran. 21	ad lib.	6	6?
101	F. Sowerby, Aylesby, N. Lincolnshire ...	112	28	Cut Oat Sheaf.		...	ad lib.*	8	0?
	THE SPRING SEASON.								
102	Professor Low—Elements of Agriculture ...	140	73	...	...	Potatoes. 70†	...	9	9
103	,, ,, ...	140	105	...	...	...	...	12	0
104	— Binnie, Seton—H. Soc., 1850	84	70	...	500†	Linseed. 3½	ad lib.	9	9
105	W. Gater, Botley F. Club	168	...	32*	...	Pollard. 2½ bushels.	...	8	6
106	J. Twynam ,, ...	112	84	16	...	...	...	10	3
107	R. Baker, Writtle, Essex	70	70	30	...	...	140	9	0
108	T. P. Dods, Hexham	ad lib.	120*	...	...	...	...	10	6?
109	T. Baldwin, Glasnevin	147	98	...	Carrots. 49	...	...	11	6
110	C. Howard, Biddenham	ad lib. ½	42	...	Green Rye. ad lib. ½*	...	...	7	6?
111	D. A. Milward, Waterford	32	70	...	Turnips. 280		32	8	0
112	A. S. Ruston, Isle of Ely	ad lib. ½*	84	...	Green Rye. ad lib. ½*	...	...	10	0
113	A. Simpson, Beauly, N. B.	168	70	14	...	...	24	10	0
114	H. J. Wilson, Sherwood, Nottinghamshire ...	42	37½	...	Carrots. 21	Bran. 21	ad lib.†	8	0
115	E. W. Moore, Coleshill, Berks	112	63	...	...	...	ad lib.*	10	0

(3.) I have now to take from this table such particulars as will enable me, in a number of selected instances, to calculate the cost of horse keep per annum; and this I am able to do in thirty-five cases. They are arranged in the following table, in which the first and second columns give the number and authority of the case, and the last column gives the calculated yearly cost of the food described in the intervening spaces where the *numbers* of the several rations given in Table I. are quoted, with the number of weeks during which each was followed.

No.	Name.	Number of weeks (beginning Jan. 1) of each ration.	Annual Cost. £	s.	d.
1	Professor Low ...	4 (35), 9 (102), 9 (103), 17 (2), 4 (22), 4 (34), 5 (35)	22	6	0
2	— Binnie	20 (41), 6 (5), 13 (6), 13 (41)...	27	9	6
3	Wm. Thomson ...	26 (43), 13 (7), 13 (43)	24	14	0
4	— Barthropp ...	9 (46), 13 (45), 4 (8), 9 (9), 13 (45), 4 (46)	27	0	0
5	Mr. N., Gloster ...	22 (47), 17 (11), 13 (47)... ...	25	14	6
6	J. Morton	22 (48), 17 (10), 13 (48)... ...	26	5	0
7	W. Gater	13 (49), 13 (105), 13 (12), 13 (24)	22	2	0
8	J. Twynam ...	4 (50), 13 (106), 26 (14), 9 (50)	18	16	0
9	W. C. Spooner ...	9 (80), 18 (25), 13 (13), 8 (25), 4 (80)	22	12	0
10	T. Aitken	23 (81), 11 (3), 4 (26), 5 (27), 9 (81), ...	22	11	0
11	G. W. Baker ...	23 (82), 11 (3), 18 (82)	24	0	0?
12	R. Baker	4 (83), 9 (84), 9 (107), 17 (16), 9 (107), 4 (83)	18	18	0?
13	J. Coleman ...	22 (85), 15 (16), 15 (85)... ...	18	5	0
14	T. P. Dods ...	6 (86), 18 (108), 10 (3), 6 (28), 7 (29), 5 (86)	23	3	0
15	T. Baldwin ...	9 (87), 17 (109), 13 (15), 13 (87)	26	6	0
16	J. Cobban... ...	22 (88), 19 (17), 11 (88)... ...	18	7	0
17	S. Druce	22 (89), 19 (17), 11 (89)... ...	18	0	0?
18	C. Howard ...	17 (90), 11 (110), 11 (1), 13 (90)	19	6	0
19	J. Laidlaw ...	22 (91), 17 (7), 13 (91)	21	14	0
20	J. J. Mechi ...	22 (92), 13 (3), 17 (92)	19	10	0
21	D. H. Milward ...	9 (93), 8 (111), 13 (10), 9 (3), 13 (93)	20	0	0
22	E. W. Moore ...	19 (115), 11 (18), 5 (19), 10 (18) 7 (115)	26	3	0
23	W. Pope	17 (94), 22 (3), 13 (94)	21	15	0
24	S. Rich	19 (95), 24 (20), 9 (95)	24	2	0
25	A. S. Ruston ...	19 (96), 7 (112), 13 (1), 13 (30)	20	4	0?

No.	Name.	Number of weeks (beginning Jan. 1) of each ration.	Annual Cost.
26	H. E. Sadler ...	13 (97), 6 (103), 17 (16), 14 (103), 4 (97)	24 5 0
27	M. Sandford ...	19 (98), 20 (3), 13 (98)	16 6 0
28	A. Simpson ...	15 (99), 7 (30), 21 (3), 4 (31), 5 (99)	19 0 0
29	F. Sowerby ...	26 (101), 13 (21), 13 (101) ...	19 10 0
30	H. J. Wilson ...	9 (100), 13 (114), 6 (7), 7 (3), 4 (32), 9 (33), 4 (100)... ...	20 8 0

No.	Name.	Quantity of food consumed in the year.	Annual Cost.
31	Professor Low ...	Oats, 125 bush.; hay, 36¾ cwt.; green food, clover, &c., £5	28 15 0
32	J. Melvin	Oats, 132 bu.; bran, 5 cwt.; barley, 24 bu.; grass, 3 tons; turnips, 3 tons; pasture at night 3 months...	30 16 0
33	R. Baker	Oats, 64 bu.; hay, 40 cwt.; grass, &c., 7 tons; beans, 20 bush.	24 2 0
34	J. Gibson	Oats, 85 bush.; turnips, 58 cwt.; potatoes, 58 cwt.; grass, &c., 22 weeks at 5*s.* 3*d.*	22 17 6
35	J. J. Mechi ...	Oats, 68 bu.; grass, &c., ½ acre; red clover, 2½ acres; hay, 2 tons	30 4 0

A review of these tables shows that the differences in the cost of weekly food, according to the various modes of feeding specified, are very considerable; amounting to more than 100 per cent. in the cost of summer feeding, which averages 8s. a week, and varies from 5s. to 11s.; to seventy or eighty per cent. in the cases given of autumn feeding, which costs on the average about 9s. 6d., and varies from 7s. 6d. to 12s.; to more than 100 per cent. in the cost of winter feeding, which averages about 6s. 4d., varying from 4s. 9d. to 12s.; and to thirty per cent. in the cost of spring feeding, which averages nearly 10s. a week, varying from 7s. 6d. to 12s.

I find that the average cost per week of keeping a horse throughout the year, according to the cases here described—putting the summer season down as lasting eighteen weeks, the autumn as six weeks, the spring as lasting over twelve weeks, and

the winter season as sixteen weeks—amounts to about 8s. weekly. The annual cost in some of the cases named is, however, brought out more accurately in the second table, where the average annual cost of thirty-five selected instances comes out as equal to £22 7s., being about 8s. 7d. weekly throughout the year.

It is plain that these two tables need to be studied and compared rather than merely read; and the reader must, for the most part, be left to gather in this way the information they convey, for it would take more pages than can be spared to state in words the facts of the three dozen histories which are here compendiously expressed in figures. One remark, however, may be allowed. Thus, the discrepancy ought to be pointed out which exists between the annual cost of horse keep as calculated from the detailed statements of one or two authorities, and the cost as calculated from the quantities estimated by the same authorities as being consumed during the year. Professor Low's weekly dietary costs £22 a year, while his statement of quantities consumed in the course of the year comes to £28 15s. per annum; and it is so with the reports of Messrs. Baker of Writtle, and Mechi of Tiptree. As to the relative values of the differing statements, it will, I think, be safer to accept the calculated results of the given weekly consumption than to trust to the estimated annual quantities consumed. Some of the differences (amounting to twenty-five or more per cent.) may be owing to different rates of valuation having been adopted in the two cases respectively.

The chief point, however, to which attention will be given in this table is the large difference of annual cost per head incurred under different modes of management in the maintenance of the horses of the farm. Mr. Sandford pays £16 6s. per head per annum; Mr. Melvin pays £30 16s. per annum—nearly twice as much. One must not too confidently infer from such a difference per head a similar difference in the cost of horse labour *per acre*. The less expensive method is not necessarily the cheaper of the two, as these very farms sufficiently illustrate. In Mr. Sandford's case twelve horses are used (consuming, therefore, £195 12s. worth of food, or 16s. 3d. per acre) in cultivating 240 acres of "a marl on a chalk subsoil, from six to seven inches deep." That it is well done may be inferred from the good crops grown in the year of the report, reaching forty-four bushels of wheat over sixty acres, and fifty bushels of barley on a similar extent. In Mr. Melvin's case twenty horses are employed (consuming, therefore, £616 worth of food per annum, or about 18s. 9d. per acre)

in cultivating 675 imperial acres, "part of it eight to eleven inches deep, the rest seven or eight—the lea furrow being six inches deep." It is right to add that Mr. Sandford's farm includes sixty acres of grass land, which, however, does not greatly add to the labour of the horses. But the difference between £31 and £16 6s. (eighty-nine per cent.) does not merely dwindle down to one between 18s. 9d. and 16s. 3d. per acre (fifteen per cent.); it still further diminishes when considered in connection with the quantity and laboriousness of the fallow crops in the two cases respectively. But this will more plainly appear when the other items going to swell the cost of horse labour—namely, wages of team-men, farrier's and tradesmen's bills, annual cost of keeping implements and animals good—are enumerated, and when the number of horses kept, and the extent of the different crops cultivated by them are given for comparison. My reference now to the two extreme cases in Table II., is merely to guard against the idea that the cheapest management of horses necessarily implies the cheapest production of horse power.

I may allude to some of the instances here given as agreeing remarkably in their cost per annum, all of them being adopted by excellent practical farmers, and illustrating what seems to me an economical and yet efficient style of management. I refer to Nos. 13, 16, and 17, in Table II., by Messrs. Coleman, Cobban, and Druce, where the annual cost of a horse is little more than £18, or 1s. a day, each pair working fourteen to sixteen acres of fallow crop annually.

14. Extras in the Cost of Horse Labour.—Besides the food of the horse, there is the cost of blacksmith's, saddler's, and farrier's bills, the annual loss of value by increasing age, the wages of horse men and stable boys, and the tear and wear of the implements by which the horse power is utilised in cultivation, to be taken into account; there is also the number of horses with their men kept upon the farm, to be considered before we can estimate the cost of horse power per acre on the farm. The extras enumerated above may be valued thus per horse:—Blacksmith's bill for shoeing, 30s. annually; farrier's bill, per annum, 10s.; saddler's bill, per annum, 10s.; depreciation of value, ten per cent., say £3, the whole thus reaching £5 10s. per annum. But on these points I add a number of notes received from those to whom I owe the particulars given in Tables I. and II. The numbers heading each paragraph in the following pages are those of Table II., which may be referred to.

(10.) "Since I joined my father in my present occupation in 1841 I have the account of horses purchased; and as our practice has been to buy only for making up our teams, and, with only one exception, at an age to be put to work immediately bought, so that nothing is chargeable to keeping, and I consider our present team superior to what I commenced with, it is, I think, a very fair criterion. The cost of farrier will lead you to suppose we have been tolerably healthy; it includes attendance on cattle, and I believe nearly half should be charged to cattle account.

"Our blacksmith's bills include work done to machinery and fencing, &c., which does not properly belong to horse labour.

"Our shoeing will be very much less than in most localities. [It is a fen soil.]

"The saddler's account, you will see, is in excess: it includes harness for gig and riding.

"The implements are far below your estimate, though I think mine are in good order, and fully capable of well working our occupation. I have not employed either a wheelwright or blacksmith on the premises, so that all my expenditure has come in bills, and it is very easily ascertained. Our total expenditure for seventeen years is as follows:—

	Horses.	Farrier.	Blacksmith.	Saddler.	Implements.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
	678 18 0	50 12 0	370 15 7	244 13 2	550 15 0
Average per Annum, say	40 0 0	3 0 0	22 0 0	14 10 0	32 0 0

"The extras you charge £5 10s. would in our case, reckoning for twenty horses, only amount to £4; that is £2 per horse for depreciation, 3s. for farrier, £1 2s. blacksmith, 15s. saddler. On further consideration I should be inclined to put the charge for extras at £4 10s. per horse."

(14.) "My smith's account, including cast-iron shares for the plough, has not averaged £16 per annum; and my carpenter's account from £5 to £6 annually. The farrier's bill does not exceed £2 per annum, and the saddler costs £5 a year. These sums divided by eight, the number of horses [and deducting for work on implements], amount to £2. Ten per cent. on £30, the value of the horses, makes the sum in my case £5, instead of £5 10s."

(17.) "I contract with a blacksmith to shoe my horses at 10s. per horse per year, and a similar sum to the harness-maker. I

think a deduction should be made for the pasture land; the expenses on the grass portion of my farm amount, I find, to about 3s. per acre annually."

(18.) Mr. Howard contracts for the shoeing of his horses at 11s. each; the charge of 30s. for this is, in his case, too high, but it includes smith's work on repair of implements. He also keeps a pair of extra job-horses, used in busy times; all which must be borne in mind when considering the accuracy of the figures in his case.

(19.) "I believe I can say what few of your correspondents can say, that £1 per horse will cover our farrier's bill for all the seventeen years we have been farming. I attribute this in great measure to a uniform system of feeding."

(25.) "I put out my shoeing for £11 per year—twenty-nine work-horses and generally three nags. On our fen soils shoes wear out slowly."

(29.) "Your estimate of extras approximates very nearly to what I see mine cost. The following is the amount of my extras for the last four years:—

	Saddler.			Blacksmith's Contract.			Farrier's Contract.		
	£	s.	d.	£	s.	d.	£	s.	d.
1855	19	7	0	36	0	0	7	0	0
1856	14	4	6	36	0	0	7	0	0
1857	12	0	0	36	0	0	9	0	0
1858	15	12	0	36	0	0	7	0	0
	61	3	6	144	0	0	30	0	0
Per annum ...	15	5	10	36	0	0	7	10	0
Per horse ÷ 22...	0	13	10½	1	12	9	0	6	10

	£	s.	d.
Amount in all	2	13	5½
Add for annual depreciation ...	3	0	0
Total amount	5	13	5½

to which you are sufficiently near."

(30.) "The actual shoeing of twenty horses for eleven months has been £14 4s. 8d., which for twelve months would give £15 10s. 6d. per annum, or 15s. for a horse annually. For the same twelve months the cost of replacing the merely 'wearing parts' of ploughs, harrows, &c., has been about £25, which, I believe is below the average. This is a pretty good illustration of the character of our soil. Our farrier costs us £18 a year,

of which £10 may belong to the horses, costing 10s. yearly each."

(32.) "We reckon the annual depreciation in value of a £30 horse at £3, and of course £4 10s. on a £45 horse. The smith's accounts come to £3 10s. per pair for maintaining everything belonging to or wrought by the horses, but not furnishing anything new. The saddler's account costs from 15s. to £1 15s. per horse, according to the style and keeping of harness. Insurance per horse amounts to £1 on a £30 horse; and my experience, where horses are fully fed and hard wrought, declares it to cost that sum. My farrier's account does not reach 5s. per horse."

In addition to the expenditure in shoeing, saddlery, and the other items specified, the annual tear and wear of implements has to be considered. This may be put at ten per cent. of the value of the implements, which being estimated at 20s. per acre over the arable land, results in a charge of 2s. per annum on this account.

Lastly, the wages of team men constitutes an important extra in cost of horse power. These I give in some of the cases specified in Table II., by extracts from the reports received.

(10.) "We are giving our ploughmen 12s. per week at the present time, with house and garden free; 20s. a week for four weeks in harvest, and twenty bushels of potatoes. Last year we gave 13s. 6d., and the year before that 13s. Taking an average of years, I suppose it would be barely 12s.

The account here, therefore, stands thus:—

	£	s.	d.
Ten ploughmen at 12s. for forty-eight weeks ...	268	0	0
Ditto at 20s. for four weeks	40	0	0
Two hundred bushels potatoes, at 2s. 6d.	25	0	0
Cottages and gardens, say	40	0	0
	373	0	0
Deduct for harvest money and sundry employment	73	0	0
Charged against the horses	£300	0	0

I give the calculations in this case in detail, but the reader must be left to work it out for himself in the other instances:

(11.) "The ploughmen now are paid 2s. a-day. Of course their wages fluctuate according to the price of provisions. They generally get an advance of 2s. per week for four weeks during

haymaking, and they are paid 20s. a week for a month during the corn harvest; and they have the privilege of working by contract whenever opportunity offers during hay time or harvest. It will not, therefore, be fair at such times to charge the whole of their wages to the cost of horsekeeping."

(13.) "Three of the ploughmen are paid 11s. a week, and receive 36s. extra for harvest. Two boys get 7s. a week, and about 15s. extra for harvest work. No beer or extras of any kind beyond the wages. The carters groom but do not feed their horses; a regular horse-feeder is kept, who employs about half his time at this work, and is paid 12s. per week, and 32s. extra for harvest work."

(14.) "The general wage of a full ploughman has been for the last few years 15s. or 16s. a week, with from two to four bushels of wheat, the same of barley, eighty stones of potatoes, and a house free, and cartage of coals. He is bound to supply a woman-worker at 1s. a day in summer, 1s. 6d. in harvest, and 10d. in winter. Some men get less and some few more than this: my own wages are 15s. with the lesser quantities of corn."

(15.) "The ploughman's wage is 12s. a week, with a free house."

(16.) "We pay our ploughman 10s. a week."

(17.) "The wages of the ploughman are from 12s. to 14s. a week."

(18.) "My horsekeeper's wage is 12s. a week; my under ditto and ploughmen from 8s. to 10s., with double wages for the harvest month."

(19.) "The wages of the ploughmen are above the common rate of the neighbourhood: they receive 11s. 6d. in money, besides beer and extra money in harvest, also a house and garden, worth £5 a-year."

(21.) "Ploughmen get 8s. 6d. a week."

(22.) "Carters' wages 15s. a week, including rent, fuel, beer, and indulgences." (Boys' wages not stated.)

(23.) "One man and boy are allowed to a team of four horses. The ploughmens' wages are from 8s. to 9s. per week, with house, garden, fuel, and twenty perches of potato ground, and 1s. for every journey above six miles from the farm.

(24.) "Carters 15s. a week (no perquisites). Young men and boys hired by the year, from 3s. to 9s. a-week."

(25.) "We have no hiring of servants, but our ploughmen are ordinary labourers, taking the ordinary wages—just now 10s. per week; when corn is dearer, 12s. a week."

(26.) "The wage of the ploughman is usually more than that of the ordinary labourer by 1s. a week and a house rent free. And for four weeks during harvest they have double wages. Their wages for the year, including rent of house, would amount to £35 *now* (1859)."

(27.) "The waggoners have 2s. a week more than the labourers, who are now paid 11s. a week. The second man has 1s. less than the waggoner, and both have £2 10s. for harvest. The 'all-workers' have 10s. per week all the year round. The boys have 7s. per week for board, and £6 wages." (Four horses to a team.)

(28.) "The ploughmen are engaged by the year, and the money wages, with allowance of provisions (valued at wholesale prices), amount to £30 per annum, besides a cottage on the farm."

(29.) "Ploughmen about 12s. a week."

(30.) "Ploughmen's wages, 15s. to 17s. a week, except for a month in harvest, when they have from 25s. to 35s. per week."

(32.) "Ploughmen's wages may amount in all to 16s. per week, varying from 12s. 9d. to 14s. 3d., according to price of grain; namely—house, £21; 1,050 lbs. of oatmeal, 10 cwt. of potatoes, cartage of coals, and food for four weeks in harvest time."

(6.) "Head-ploughman, 13s.; the others, 12s.; boys, 6s. a week."

These particulars are given in explanation of the varying nature of these items in the cost of horse power; though even they do not convey the whole truth on the subject; for, in addition to varying wages, the number of men and boys to a given number of horses varies exceedingly. And it will be seen in the following section that the information here given goes only partly to account for the figures in that column of Table III. which specifies the wages of team men.

15. Cost of Horse Labour per Acre.—We are now in a position, with reference to the cases already specified, to ascertain the whole amount paid for horse labour on a number of selected farms; and, comparing it with the acreage of the several farms, to state the cost per acre of the horse labour on each. This is done in the following table, in whose columns are stated (1) the numbers of the cases severally quoted from Table II.; (2) the annual cost of food per horse taken from Table II.; (3) the estimated or the actual amount, given under the head of extras, of blacksmith's, saddler's, farrier's bill for horse, together with the cost of maintaining the value of the animal undepreciated; (4)

the number of horses worked upon the farm; (5) the total cost of horse-keep on the farm, as made up of food and "extras;" (6) the cost of maintaining the implements in use at an undepreciated value—viz. ten per cent. upon an estimated expenditure of £1 per acre of the arable land; (7) the amount of wages paid to team men, as calculated from the particulars supplied to me, and partly explained in sundry notes already given; (8) the total cost of horse labour on the farm; (9 and 10) the total acreage of the farm in arable and pasture land; (11 to 14) the acreage of the several crops cultivated on the arable land—fallow and fallow crops, including bare fallow, turnips, carrots, mangold-wurzel, cabbage, &c.—grain, including wheat, barley, oats, &c.—clover, including clover, sainfoin, lucerne, &c.—and pulse, &c., including beans, peas, and flax; (15 and 16) the cost per acre of arable land, and per acre of the actually ploughed land, of the horse labour of the farm.

It may be stated here, in explanation of the large amount of extras under No. 6, that they included in that case a considerable portion of the cost of implement repairs. The wear and tear of implements also, however, stand rather higher here than in the proportion which the others present to their respective acreage; the fact being, that on this farm a great deal of machinery had been tried, the repairs of which were a heavy item.

Columns 2, 3, 4, 6, and 7, give us the means of calculating the total cost of horse labour, which accordingly appears in column 8.

In columns 9 and 10 we have the acreage occupied by the tenants in the several cases specified. Of course it would be of little service to compare the total cost of horse labour with the total acreage, because much of it might be pasture, involving little labour of any kind. The extent of arable land is accordingly given, and the cost of horse labour is calculated in column 15 per acre of the arable land in every case. But even this would mislead without further explanation, and accordingly in columns 11, 12, 13, 14, will be found the acres respectively in fallow and fallow crops, in grain crops, pulse, and clover. And in column 16 the cost of horse labour per acre ploughed that year is calculated. But even these particulars are insufficient to enable a perfectly truthful comparison, for the soil may be stiff or light, and the cultivation may be deep or shallow.

Take, for instance, one of the last cases (30) in the above table. Mr. Wilson's farm is an extremely light sand, just enclosed out of

TABLE III.—VALUATION OF HORSE LABOUR.

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
Number in Table II.	Annual Cost per Horse.		Number of Horses.	Total.	Annual wear of Implements.	Wages of Teammen.	Total Cost of Horse-labour.	Acreage.		Acreage.				Cost per Acre of Horse-labour over	
	Food.	Extras.						Pasture.	Arable.	Fallow Crops.	Grain Crops.	Clover, &c.	Pulse, &c.	the Arable Land.	the Ploughed Land.
	£ s.	£ s.		£ s.	£ s.	£ s.	£ s.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	£ s. d.	£ s. d.
10	22 11	4 10	20	541 0	32 0	300 0	873 0	...	660	119	330	110	110	1 6 6	1 11 9
11	24 0	5 10	20	590 0	70 0	332 0	992 0	400	560	110	280	140	...	1 15 5	2 7 2*
13	18 5	5 10	11	261 5	40 0	170 0	471 5	43	400	91	182	85	42	1 3 6	1 10 0
14	23 8	5 0	8	225 4	31 0	176 0	432 4	110	310	78	155	57	20	1 7 10	1 14 0
15	26 6	5 10	5	159 0	12 16	85 0	256 16	41	128	32	54	37	5	2 0 0	2 16 5
16	18 7	5 10	7	166 19	20 0	104 0	290 19	400	210	50	100	50	...	1 9 0	1 18 9*
17	18 0	5 10	7	164 10	20 0	116 0	300 10	100	200	50	100	50	...	1 10 0	2 0 0
18	19 6	4 10	12	285 12	33 0	170 0	488 12	120	330	77	175	68	10	1 10 6	1 17 4
19	21 4	5 0	7	183 8	25 0	120 0	328 8	60	250	63	125	42	20	1 6 3	1 11 7
21	20 0	5 10	12	306 0	30 0	132 12	468 12	...	300	75	150	75	...	1 11 3	2 1 9
22	26 3	5 10	11	348 3	34 0	179 8	561 11	400	340	90	150	45	55	1 13 0*	1 18 1*
23	21 15	5 10	14	381 10	40 0	200 0?	621 10	400	400	120	185	80	15	1 11 1*	1 18 10*
24	24 2	5 10	12	355 4	40 16	170 0?	566 0	274	408	60	174	174	...	1 7 9*	2 0 0*
25	20 4	4 10	29	716 6	90 0	364 0	1,170 6	120	900	235	450	150	65	1 6 0	1 11 2
26	24 5	6 5	16	488 0	50 0	219 15	757 15	75	500	120	240	140	...	1 10 0	2 2 1
27	16 6	5 10	12	261 12	24 0	158 4	443 16	6	240	50	120	60	10	1 17 0	2 9 3
28	19 2	5 10	10	246 0	34 0	150 0	426 0	...	300	100	150	50	...	1 8 4	1 14 0
29	19 10	5 10	22	550 0	60 0	291 4	901 4	...	600	150	300	150	...	1 10 0	2 0 0
30	20 8	5 10	20	518 0	90 0	348 16	956 16	...	900	200	340	340	20	1 1 6	1 14 0
32	30 16	5 10	20	726 0	67 10	338 0	1,131 10	...	675	125	300	200	50	1 13 6	2 7 8
6	26 5	8 0	7	239 15	30 0	117 0	386 15	...	240	60	120	30	30	1 12 2	1 16 10

* The instances marked with an *asterisk* are those of pasture farms as well as arable. From 3s. to 4s. 6d. per acre for horse labour on the pasture should be deducted from the sums in column 8; and the remainder, spread over the arable land of the farm, will give figures more correct. For example, Mr. Baker, of Woburn, whose pasture land costs him 4s. 6d. an acre for horse labour, would thus have the figures 35s. 5d. reduced to 32s.

the heathy waste of Sherwood forest. He has cultivated it generally five to seven inches deep, excepting one deep ploughing in preparation for turnips, which is about ten inches deep; and yet a day's work at plough varies from one acre of deep work, to one and a half or even more of light fallow ploughing. The average of all sorts will be at least one and a quarter acre done daily per pair of horses in eight or nine hours. No wonder that Mr. Wilson's horse labour cost less per acre than the others, whatever his method of stable feeding may be; for heavy land cannot of course be cultivated for the same expenditure as light and sandy soil. In order, then, that the figures of these last columns of Table III. may be read intelligently, I add another series of extracts from the reports, stating the ordinary depth of cultivation adopted in the several cases, and the character of the soil. The figures numbering the paragraphs are the same as those of Tables II. and III.

(10.) "The soil is peat upon clay, over say one-half of the farm; over the remainder the clay is ploughed up, and it needs a great deal of rolling to give it sufficient solidity for the wheat crop. The ploughing may be averaged for a pair of horses to do one and a quarter acres daily. The general depth of cultivation is five inches; for, though we plough deeper for fallow, yet the peat decomposes, and we lose the depth in the course of a year, and we find it prejudicial to any other crop to plough deeper than it was fallowed."

(11.) "About 100 acres are strong land, but not so retentive as to prevent its being ploughed ordinarily with two or three horses. The remainder (460 acres) is a sandy soil. It has all usually been cultivated from five to six inches deep."

(13.) "Two hundred and sixty acres are a useful marl with stones; the soil deep enough to allow of seven-inch ploughing, and sufficiently retentive (often containing fifty or sixty per cent. of clay) to render it stiff working land in moist weather. One hundred acres are of a light and shallower soil, sometimes occupying the slopes of the hills, where we may not have more than two inches of earth. Forty acres are a strong clay marl. Three horses in line are needed for six to seven-inch ploughing. From one acre (lea ploughing) to three quarters (in winter) is a day's ploughing."

(14.) "Except seventy acres of strong soil, part of which is very steep, my farm is flat alluvial soil, partly light and partly good deep loam—all good turnip land. Fallows are ploughed

eight to nine inches deep with two horses, twelve to thirteen with three horses, whenever the land allows; lea land is ploughed six to six and a half inches deep; turnip land for corn five inches."

(15.) "The soil is a loamy clay, of a darkish brown colour, resting on the middle limestone formation."

(16.) "Of the soil, twenty acres are light and shallow, resting on limestone rock; 100 are a lightish sandy loam; and eighty are a clayey loam. We plough a foot deep for roots, four inches deep for corn."

(17.) "The character of the land is gravel, clay, and clay loam. Our ordinary depth of cultivation is from five to eight inches—never less than the former. The ordinary day's work varies from three roods to an acre, the horses working double."

(18.) "The character of the soil over 230 acres is gravel, liable in a dry time to burn; over 100 acres a black gravel and loam. For wheat we plough four to five inches deep; for barley four inches; our turnip fallows from eight to nine inches. We usually expect a man with a pair in ordinary work to do his acre in the day, excepting in winter, when the fallows are laid up with four horses in a plough, and in spring, when these fallows are ploughed back, with a three-horse plough."

(19.) "The soil over most of the farm is a gravel, and on the rest a stiff clay. We plough six or seven inches deep, except for roots, when the furrow is ten or twelve inches deep."

(21.) "We use two-horse swing-ploughs, and three roods to an acre are a day's work; on short days, of course, we must be satisfied with less."

(22.) "We have a deep loam on the west side of the farm, and can plough safely and usefully nine or ten inches; on the south side we have a strong loam on clay, the average depth being six or eight inches; on the east side a very useful stonebrash, cultivated six inches deep; on the north side it is pasture. The ordinary extent of a day's work at plough is an acre; three horses are used ploughing for beans and fallow in the autumn, two being used for all else after the first spring furrow."

(23.) "The soil varies much, and in a dry summer is very difficult to work. It is cultivated from four to six inches deep. Three horses are used in a plough for 'breaking' grass and heavy stubble, and two only for the after-ploughings. From three roods to one acre is about a usual day's work for one plough."

(24.) "Soil chiefly a light stonebrash, like most of the Cotswold district; but there are some sand and some clay spots. It is

cultivated four to five inches deep, or more when the soil admits. Half an acre, or rather less, is a day's work, taking the average of dry and wet with the distance from the stables. Generally two, sometimes three horses are used in a plough."

(25.) "The soil on the fen farms is very light and non-adhesive; on the high lands more tenacious and heavy. Many fen farmers break up a good deal of their clean fallow lands with four or six horses in a large plough, bringing up the subsoil and mixing it with the top soil. They plough from fourteen to fifteen inches deep; but the usual depth of ploughing is, for wheat, five or six inches; and on the high lands we cultivate from six to eight or nine inches deep. Two horses easily plough five roods a day on the fen. On the high lands early in the season, two horses will plough from three to four roods per day; but in winter and spring, when the land gets wet and sticks a good deal, we usually plough with three horses at length, to avoid treading, and they plough just three roods daily."

(26.) "Three-fourths of the farm is a light chalky soil, the remainder a rather stiff red gravel resting upon the chalk. The wheat stubbles are usually ploughed about seven inches deep in the autumn by three or four horses. The average depth for wheat, barley, &c., is about five inches. An average day's work is a statute acre, done by a pair of horses abreast."

(27.) "The soil is a marl on a chalk subsoil; the depth of cultivation is from six to seven inches. An acre and a quarter to an acre and a half is a day's work—four horses to a team."

(28.) "One hundred and twenty acres are a clay mould; 120 acres peaty, on a sandy subsoil, but damp—reclaimed from swamp; fifty-five acres sharp gravel. The ordinary depth of furrow is eight inches; if subsoiled, fifteen inches.

(29.) "Soil loamy, with clay subsoil. Ploughing six to seven inches deep. Three roods a day in winter; one acre in summer by two horses."

(30.) "Soil varying from mere sand to gravelly sand, and in places many boulders. The depth of cultivation varies according to crop from five to seven inches, except one deep ploughing in preparation for turnips from ten to eleven inches. A day's work at plough varies from one acre of hard work to one and a half, or even more, of light fallow ploughing; ploughing clover lea for wheat, one and a quarter acres per day; and perhaps the average ploughing of all sorts is one and a quarter acres daily, done in eight or nine hours—two horses to a team."

(32.) "Soil medium. Lea furrow six inches deep. Part ploughed in autumn, eight to eleven inches deep, rest, say seven or eight."

(6.) "Soil, a sand over 140 acres; a clayey loam over eighty acres; a light brashy soil over twenty acres. Ploughed from five to ten inches deep, according to the crop."

Even the extremely various character of the land, and the great differences in the treatment of it, as above described, fail, however, to account for the whole of those differences in the price of horse labour per acre which Table III. describes. There is a large remainder after the amplest deductions on this ground, which must be put down either to varying stable management on the one hand, or to varying laboriousness of cultivation on the other. The number of acres cultivated per horse—*i.e.* excluding from the whole acreage of the farm, not only the permanent pasture-land, but the extent in clovers and grasses—varies exceedingly; no less, indeed, than from eighteen and fifteen, in the case of Nos. 15 and 27, to thirty-one and thirty in the case of Nos. 14 and 6. From the accounts which have been given me, there does not appear to have been that greater laboriousness of cultivation, either involuntary, arising from the character of the soil, or voluntary, arising from deeper and more frequent cultivation, which would explain such differences as appear in these tables. The further information which is to be extracted from a study of them must be left to be gathered by the reader, but it is worth while pointing out to him how the number of horses kept on a given extent of land overrules in its ultimate effect the most economical style of stable management. Mr. Sandford's horses cost him only £16 6s. each per annum for their food, *i.e.*, about half as much as those of Mr. Melvin; and yet the expenditure of the latter per acre for horse labour, high as it is when compared with the other cases on the list, is not so high as that of Mr. Sandford.

It may be added, as presenting the total result of the instances specified in this table, that we have on twenty-one farms 282 horses, costing for food, for depreciation of value, and for saddler's, farrier's, and blacksmith's bills, £7,713 a year; their implements cost £874 a year to keep them good; and the ploughmen and boys employed about them cost £4,242 a year in wages—in all, about £13,000, or £46 per horse per annum; and supposing that there are 2,500 working hours in the year, this is rather less than 5d. per horse per hour.

16. Cost of Horse Power per Cwt. of Draught.—The common definition of horse power is the ability to lift 33,000 lbs. one foot high per minute. This is perfectly consistent, as has been already said, with the results of experiments on the draught of ploughs. Thus, when two horses pull a plough along at the rate of two and a half miles in an hour, and the tension on the draught chain is equal to a lift of 300 lbs.—no uncommon case—they do in effect lift that 300 lbs. 220 feet per minute, that being the sixtieth part of two and a half miles; and this is equivalent to a lift of 66,000 lbs., or just the 33,000 lbs. apiece, one foot high per minute, which is the ordinary mechanical expression of one-horse power. This power, however, is not continuously exerted. The plough, though drawn at the rate of two and a half miles per hour, is not drawn twenty-five miles in a day of ten hours; it is not often drawn much more than ten miles in that time, in consequence of loss of time on headlands, &c. In fact, the plough is drawn barely ten miles in turning over one acre in furrow-slices ten inches wide. In this lies one great difference between animal and steam power, namely, the persistence of the latter, if only methods of continuously employing it can be devised. The really effective work of a horse per diem thus does not much exceed one half of that calculated from its work per minute; and its annual performance must be often still further reduced below the theoretical standard by the occurrence of days when it remains idle in the stable.

In some of the instances described above, I have received such a detailed account of the work done upon the farms, as enables me to estimate with some confidence the *total* annual draught accomplished during its cultivation. The following, for instance, were the details of cultivation on my father's farm at Whitfield. On 120 acres of it wheat was annually grown; the cultivation of this consisted of one ploughing, three harrowings, one drilling, one rolling, the carting of the produce (two tons per acre) three-fourths of a mile to the homestead, and the carting of some 100 tons of grain perhaps six miles to market. On sixty acres of root-crops there were one deep ploughing, and probably two shallower ploughings, three "cultivatings," probably ten harrowings, two rollings, twice ribbing when covering the manure, one drilling, three horse hoeings, the carting of fifteen tons of dung per acre to the land, and the carting of twenty-five tons of produce from the land three-fourths of a mile. On thirty acres of clover there was one rolling, and the carting of fifteen tons of green food per acre

from ten acres, and the carting of twenty tons of hay off ten acres three-fourths of a mile. On thirty acres of beans there were two ploughings, two "cultivatings," four harrowings, one drilling, two horse hoeings, ten tons of dung per acre carried three-fourths of a mile, two and a half tons per acre of produce carried home three-fourths of a mile. I have the number of miles walked per acre in performing every operation, and I can from experience and experiment pretty nearly estimate the draught in every case. In the case of produce and manure carried I add the weight of the cart going and returning, which just doubles the quantity of cartage; and ten per cent. is charged upon the weight for draught, this being what seems to me fair, on comparing Mr. Brunel's experiments on this subject with the ordinary character of cartage on the farm.* It is plain that in all these particulars I have the complete history of the labour of cultivating and carrying the crops of the farm, which accordingly is given in the table on the next page.

These figures represent the cwts. drawn (= lifted) one mile in the several operations; and, adding them together, we have the annual labour of the farm, which amounted, in the case before us, to 37,006 cwts. drawn (= lifted) one mile per annum. For the words "per annum" we may substitute 300 days of nine hours each, and the work done will be found on calculation to have been equal to the lift of 135,085 lbs. one foot high per minute during all that time; which, as seven horses were employed, was 19,298 lbs. apiece, or above one-half the theoretical quantity—a very high average, however, as will appear from what I have already said. In order to ascertain the cost of horse power in this case, we must assume a rate of movement natural to the draught animal—say $2\frac{1}{2}$ miles per hour. The work done was 37,006 cwts. drawn (= lifted) one mile in 2,700 hours: this is equivalent to 14,802 cwts. drawn $2\frac{1}{2}$ miles in 2,700 hours, or $5\frac{1}{2}$ cwts. drawn that distance every hour. But the cost of horse labour on this farm was £386 15s. per annum, or 2s. 10d. per hour—that, then, was the cost of drawing (= lifting) $5\frac{1}{2}$ cwts. $2\frac{1}{2}$ miles in that time. Horse power on Whitfield farm thus cost as nearly as possible 6d. per cwt. drawn $2\frac{1}{2}$ miles at that rate of

* He found that the draught on a dry good road was three per cent. of the weight; on a wet good road it was four per cent.; on hard compact loam it was five and a half per cent.; on ordinary bye-roads it was ten and a half per cent.; on a newly-gravelled turnpike-road it was fourteen and a half per cent.; and on a loose sandy road it was more than one-fifth, or twenty per cent. of the weight.

HORSE LABOUR ON WHITFIELD FARM.

Crops.	Acreage.	Ploughed.		Cultivated.	Harrowed.	Rolled.	Ribbed.	Drilled.	Horse-hoed.	Dung Carted.		Produce Carted.		Equal to Carting 1 Mile.
		Deep.	Ordinary.											
		Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Tons.	Miles.	Tons.	Miles.	Tons.
Roots ...	60	60	120	180	600	120	120	60	180	900	$\frac{3}{4}$	1,500	$\frac{3}{4}$	1,800
Corn ...	120	...	120	...	480	120	...	120	...	...	...	240 100	$\frac{3}{4}$ 6	780
Clover ...	...	...	...	...	...	30	...	...	...	...	...	150 20	$\frac{3}{4}$ $\frac{3}{4}$	$127\frac{1}{2}$
Beans ...	30	...	60	60	120	...	...	30	120	300	$\frac{3}{4}$	75	$\frac{3}{4}$	$281\frac{1}{4}$
Total		60	300	240	1,200	270	120	210	300	...	...	...	...	2,989
Multiply by the miles walked per acre ...		8	10	3	$1\frac{1}{4}$	2	3	2	3	Add for weight of carts ...				2,989
Miles walked ...		480	3,000	720	1,500	540	360	420	900					5,978
Multiply by the draught in cwt.		5	$3\frac{1}{2}$	4	3	2	3	3	$1\frac{1}{2}$	10 per cent. on which is				
Cwt. of draught ...		2,400	10,500	2,880	4,500	1,080	1,080	1,260	1,350	11,956 cwt. drawn 1 mile.				

movement. If the ploughing of an acre was equal to lifting 3 cwts. ten miles, then, by horse power it was done for 6s.; if it was equal to lifting 5 cwts. eight miles (I name fewer miles, because the greater draught implies greater depth of ploughing, and deeper ploughing involves a wider furrow-slice), then it cost 8s. per acre. And these are the figures with which, if it were desired to ascertain the gain of substituting the power of steam for that of horses, an engineer would have to compare the performance of his engine.

Take now the case of Mr. Melvin's farm. In order to understand some of the figures in the cartage columns of the following Table, it is necessary to extract the following particulars from Mr. Melvin's Report. "There are 1,600 tons of manure carted two miles. Three-fourths of the grain is carted ten miles, one-fourth $3\frac{1}{2}$ miles; forty-eight tons of linseed or other cake are carted twelve miles; 120 tons of coal are carted eleven miles." (Table on next page.)

The figures on the table, let me repeat, represent the cwts. drawn (= lifted) one mile during the several operations annually; and, adding them together, we have the annual labour of the farm equal to 107,900 cwts. drawn (= lifted) one mile per annum; or substituting for the year 300 days of nine hours each, the work done will be, according to calculation, equal to the lift of 393,875 lbs. one foot high per minute during all that time, which, as twenty horses are employed, is 19,693 lbs. apiece, somewhat more than on Whitfield farm, and a very high average performance indeed. The work done annually corresponds to 43,160 cwts. lifted $2\frac{1}{2}$ miles per annum, or 15·98 cwts. per hour during the year. Now Mr. Melvin's horse labour costs him £1,131 10s. a year, or 8s. 4d. per hour during the year. Horse power in his case, then, costs rather more than 6d. per cwt. drawn (= lifted) $2\frac{1}{2}$ miles, at the rate of movement specified. If his horses walk eight miles in ploughing an acre with a five cwt. draught (which indicates very deep and heavy work), the work is done for 8s. per acre.

It is plain that the instances I have given must be taken rather as illustrations of the mode of calculation to be adopted than as conveying what is absolutely true of the two cases specified. That there are many unavoidable liabilities to error in these calculations I readily admit; but that they give an approximation to the truth will, I suppose, be generally admitted.

If you can enumerate all the operations on your farm, together

HORSE LABOUR ON MR. MELVIN'S FARM.

Crops.	Acreage.	Ploughed. Deep.	Ploughed. Ordinary.	Cultivated.	Harrowed.	Rolled.	Ribbed.	Drilled.	Horse-hoed.	Dung Carted. Tons.	Dung Carted. Miles.	Produce Carted. Tons.	Produce Carted. Miles.	Equal to Carting 1 Mile. Tons.
		Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Tons.	Miles.	Tons.	Miles.	Tons.
Potatoes ...	30	30	60	...	180	30	90	...	60	660	$1\frac{1}{4}$	180	4	1,545
Turnips ...	95	95	95	95	950	190	190	95	285	1,615	$1\frac{1}{4}$	1,800	$\frac{1}{2}$	2,920
												125	$1\frac{1}{4}$	
Beans ...	50	...	50	50	400	50	100	...	50	850	$1\frac{1}{4}$	36	10	1,620
												12	$3\frac{1}{3}$	
												225	10	
Corn ...	300	...	300	...	1,800	300	...	...	...	30	12	75	$3\frac{1}{2}$	2,870
												150	$1\frac{1}{4}$	
Clover, &c.	50	...	...	...	...	50	...	...	...	...	...	80	10	987
									Dung	1,600	2	...	...	3,200
Pasture ...	150	...	...	...	...	...	...	...	Coals	120	11	...	...	1,320
									Cake	48	12	...	...	576
Total ...	675	125	505	175	3.330	620	380	95	395	...	...	...	...	15,038
Multiply by the miles walked per acre		8	10	3	$1\frac{1}{4}$	2	3	3	3	Add for weight of carts ...				15,038
Miles walked ...		1,000	5,050	525	4,162	1,240	1,140	285	1,185					30,076
Multiply by the draught in cwt.		5	4*	4	3	2	3	1	$1\frac{1}{2}$	10 per cent on which is				
Cwt. of draught ...		5,000	20,200	2,100	12,486	2,480	3,420	285	1,777	60,152 cwt. drawn 1 mile.†				

* Mr. Melvin's ordinary depth of ploughing is somewhat greater than it was on Whitfield farm, and I estimate the draught a little higher. Two ploughings are put down against potatoes—the labour of ploughing them up, &c., being assumed as equal to one.

† I would have reduced the per centage here, as so much of it is on the turnpike road, but Mr. Melvin's farmstead is on a height, which makes the draught heavier than it would otherwise be.

with the draught incurred in accomplishing them, then you can easily convert the whole into weight lifted through a certain space in a certain time. If you can record the cost of horse food, of extras, of ploughmen, and of keeping up live and dead stock, then against the work done you can place the exact cost of doing it; and the comparison leads, as in the two cases worked out above, to the cost of horse power "per cwt. of draught, at a given rate of movement."

It would be tedious to examine in detail the other instances given in Table III.; but I may add here, as the result of such an examination, that I believe the following Table describes pretty nearly the experience of those whose names are given :—

Number on Table III.	Name.	Performance per Horse, *i.e.* lbs. lifted 1 foot per Minute.	Annual Labour.		Cost of Horse Labour.		Cost of Horse-power per cwt. drawn $2\frac{1}{2}$ miles.
			Cwt. drawn 1 mile per Annum.	Cwt. drawn $2\frac{1}{2}$ miles per Hour.	Per Annum.	Per Hour.	
		lbs.	cwt.	cwt.	£ s.	s. d.	d.
10	Aitken ...	18,250	100,000	14·8	873 0	6 $5\frac{3}{4}$	$5\frac{1}{4}$
13	Coleman	14,354	44,000	6·5	471 5	3 6	$6\frac{1}{2}$
19	Laidlaw*	16,052	30,800	4·5	328 8	2 $6\frac{3}{4}$	$6\frac{3}{4}$
30	Wilson ...	16,957	93,800	13·88	956 16	7 $3\frac{1}{2}$	$6\frac{1}{4}$
32	Melvin ...	19,693	107,900	15·98	1131 10	8 $4\frac{1}{2}$	6
6	Morton...	19,298	37,006	5·5	386 15	2 10	6

These figures, let me repeat, are necessarily mere approximations to the truth. They are given, of course, without regard to any personal bearings they may have, simply as the results to which calculation, on the data furnished to me, has led. No doubt exception may be taken to many of them; they may, however, be safely taken, both as illustrating the way in which the cost of horse power must be calculated, and also as showing that very considerable differences do exist in the expense of horse labour as it is managed on different farms.

* Mr. Laidlaw told me he sometimes draws 700 or 800 loads of Severn mud $1\frac{1}{2}$ miles in the course of the summer; and this is here added to the work of the farm, and does, of course, increase the performance of his horses.

IV. THE LABOURER.

It is proposed in this chapter (1.) to estimate the comparative cost of mere labour as done by hand power, and steam, and horse power respectively; (2.) to state what may be called the altered incidence of farm labour as regards the different powers now used in its accomplishment, *i. e.* the alteration in the shares of it which now fall to them respectively, and this will explain the increasing demand for the services of the agricultural labourer; (3.) to state the actual wages at present paid under several methods, and in different parts of the country; (4.) to describe the modes of hiring labourers on the farm; and (5.) to discuss that relation of master and servant by which the best economical and the best social result may be obtained.

17. Economy of Hand Power.—The following four instances must suffice in illustration of the cost of manual labour engaged in mere work, *i.e.* where the least degree of skill is called for.

(1.) A man will dig eight perches of land, or say 2,000 square feet nearly a foot deep in a day. In doing so he lifts probably three-quarters of it through about a foot in height, that is to say, he lifts 1,500 cubic feet, weighing at least 150,000 lbs. one foot high in ten hours' time, and to do it therefore he must maintain upon the average a lift of 250 lbs. per minute all that time. Of course, in addition to the mere lift there is the labour of cutting off this earth from the firm ground to which it was attached. In my second case, then, this portion of his labour is very much reduced. (2.) Three men will lift 100 to 120 cubic yards of farm-yard dung, and fill it into carts in ten hours' time. The thirty-three to forty cubic yards which fall to each man's share, at twelve to fourteen cwt. a-piece, weigh 50,000 lbs., and this is lifted over the edge of the cart, or four feet high—equal to 200,000 lbs. lifted daily one foot high, or 330 lbs. per minute. This is one-fifth more than in the last case. (3.) Now take a third instance, in which there is no labour in detaching the weight from any previous connection: A man will pitch in an hour's time an acre of a good crop tied in sheaves, to an average height of full six feet, on the cart or wagon. Straw and corn together such a crop will weigh more than two tons, say 5,000 lbs. In doing this he therefore lifts 300,000 lbs. one foot high in ten hours' time, or 500 lbs. per

minute. (4.) My fourth case is of much the same kind. One man, and five boys or women, equal as regards wages, and I will therefore assume equal as regards power, to three men, will throw into carts upon an average three acres of a good crop of swedes and mangold wurzels, say seventy tons in all, in a day of nine hours' length. They lift these 150,000 lbs. four feet, being equal to 600,00 lbs. one foot; or 200,000 lbs. apiece in nine hours' time, which is about 370 lbs. a minute.

These four cases indicate the mere force of a man then, at a cost of say 3d. an hour, as equal to a lift of 250, 330, 500, and 370 lbs. per minute; the two former being cases where the load has to be detached as well as lifted, and the third being performed under the influence of good harvest fare.

But now compare this even in its best case with the duty of the steam-engine, namely, the lift of 33,000 lbs. one foot high per minute for 3d. or even less per hour; and compare it with the actual average performance of the horse, 16,000 to 19,000 lbs. lifted one foot per minute for 5d. an hour. In order at the best rate named to do the work of the steam-engine, sixty-six men would be required at a cost not of 5d., but of more than 15s. per hour, and in order to do the work of the horse, thirty-two men would be needed, at a cost of 8s. instead of 5d. an hour. It is plain that if we can take much of the mere labour of the farm out of the hands of the labourer, and put it into the hands of steam power for its performance, there is an enormous amount of saving to be made in the cost of agricultural production. It is plainly folly in the labourer to think that as regards the *mere* labour of the land he can compete with either steam power or horse power. Strength of body is desirable, and sinew hardened by long practice in hard work has a considerable marketable value; for that, however hardly it may sound, is the aspect of the matter in which the interests of the labourer most directly appear; but it is clear that for sheer lift and the mere putting forth of force, horse power, and still more that of untiring steam, must grind the soul out of any body that shall pretend to competition with it. It is in the cultivation not so much of mere strength of body as of skill and intelligence that the safety of the labourer lies, and in his capability of education he is perfectly secure.

As the matter at present stands, then, and confining ourselves to that large and increasing class of operations in which the power required is great and the process almost uniform, and

looking only to the cost per unit of work done, it is plain that steam power stands first in the race, horse power is a tolerably good second, and the agricultural labourer is literally nowhere.

18. Incidence of Farm Labour.—But consider now how this superiority of elemental and of animal power comes in by the aid of machinery to affect the incidence of farm labour. A general reference has been made to this subject in a former section; and a very general reference is all that can be made to it here. It might be possible to take the case of any specimen farm, and compare its labour account now with those of a century ago, and see how, notwithstanding the immensely increased production of the land and the increased quantity of force of all kinds needed on it, yet the actual power put forth directly by the labourer is diminished. It may well be that on the land which shall nevertheless be paying the most wages per annum, all grubbing and all heavy hoeing, all mowing and reaping, all threshing, and all cutting up of roots and hay for food, are done by horse or steam power, leaving little of mere labour for the hand, except the lifting of the produce from the ground. The great demand for labourers on the farm is now for work which requires skill and carefulness, rather than mere bodily strength. Men are wanted now for clever management of tools and of machinery; for attendance on the steam engine and the horses by which these are drawn or driven; for detailed cultivation of the plants whose produce is desired in the field; and for detailed care and management of the live stock by which a portion of that produce is consumed. And yet, limited as to quality as is the labour now required upon the farm, the quantity needed of it is enhanced so much by the more vigorous cultivation which the land now receives, that more labourers are needed now than when nearly all the work was done by men alone. So much more land has now been broken out of pasture; so much less of the arable land is each year in clover and grasses; so much more of potatoes, and of mangold-wurzels, and turnips, and crops of that class, all of them laborious, are grown; so much more stock consuming the extra provision of cattle-food needs care — that though steam power is a clear addition to our resources, and horse power is by machinery now used for purposes once wholly served by hand, yet there is more work than ever for the labourer, and work demanding a better education for the men employed in it.

Here are we producers and consumers, 21,000,000 of people, living in this island, on a great farm, which, by the help of such

statistics as we possess, we may describe as nearly 18,000,000 arable acres, and probably 12,000,000 grass, employing as farm labourers, in-doors and out, about 930,000 men and 120,000 women, besides 300,000 lads and 80,000 girls, or averaging them by their probable wages, as has been done before, let us say equal in all to 1,150,000 men, or one to every seventeen acres of arable and nearly as much pasture. We feed and use some 1,500,000 horses, of which probably 800,000 are strictly for farm purposes. We are annually inventing and manufacturing labour-saving machines at an extraordinary rate; and every year at least 10,000 horses are added to the agricultural steam power of the country, which must certainly displace both animals and men to some extent. We have taken the flail out of the hand of the labourer, and the reaping-hook is going; on many a farm he no longer walks between the handles of the plough—he no longer sows the seed—he does but a portion of the hoeing and the harvesting—and yet so far from being able to dispense with his assistance, he is more in demand than ever he has been. Agriculture is, in fact, experiencing the truth taught in the history of all other manufactures—that machinery is in the long run the best friend of the labourer. It is facilitating and cheapening production, and thus promoting the general good; and labourers are realising what their masters too have lately learned, that a share in the general prosperity is worth more than the exclusive advantages conferred by a monopoly.

In every county there used to be many farms almost wholly pasture, divided by frequent, wide, and straggling hedges, and covered with scattered trees. They kept perhaps a single cow and a sheep or two, or some young stock, to every four or five acres of land, and they needed a couple of men with a little additional help at harvest time to every 100 acres. On these farms, more thoroughly cultivated now, 40s. or more per acre are now spent in wages alone, equal to the employment, at better wages too, of more than three times as much hand power as formerly, notwithstanding that much more horse power is also used, and steam power has been introduced. Over whole counties the extension of potato culture has created an increased demand for labourers. Over the whole island the introduction of guano and other concentrated manures has induced a more profitable and therefore more laborious cultivation. In many districts the change of a rotation—as for example, the retention of grass and clover only one year down instead of three, and the substitution of wheat and

perhaps mangold-wurzel for a second and third year's pasture—has created more need of steam power to thresh the increased produce, of horse power to cultivate the increased arable land, of hand power to superintend and manage the detailed cultivation of the crops, their ingathering and consumption. There is much more grain grown now than used to be, but the food for stock upon a diminished extent of land has much more rapidly increased than even that of grain; and the labour now required is that of men whose competency and skill may be trusted rather than whose mere brute strength may be wielded.

19. The Price of Labour.—The fact, whatever the explanation of it be, that labourers are in greater demand now than ever they have been is plain, from the increased rate of wages which their services everywhere command; and from the frequent discussions before Farmers' Clubs as to the best methods of obtaining and retaining their services. Thus at a meeting of the Oxford Farmers' Club, Mr. Mein, who was lately the agent to the Duke of Marlborough, read a capital paper on this very subject. His method of obtaining more men was none the less sensible for its simplicity: it was just to *offer high wages*. And this is, I presume, essentially the solution of the difficulty.

He said in effect: We have not provided constant employment nor wages at which a comfortable living can be had, and no wonder that our men have brought up their children to other trades to be better paid; we have not paid young men wages corresponding to their ability; married men have been paid at one rate, and young unmarried men have been paid at another and much lower rate; they have thus been treated as children, and no wonder they have left us. Our remedy is to improve the condition of the labourers in their cottages; to give them more regular employment and better wages (it resolves itself into this, whether a farmer upon 400 acres had better spend £100 more in labour during winter, or lose £200 at harvest time in shed and damaged corn); to give the labourers more task work, and allow them to earn fair prices at it, simply according to their ability; and lastly, on occasions of unusual pressure to give unusual wages. Even at harvest, hitherto, he said, "our prices have not been anything to compare to the daily wage of the tradesman; nay, not enough to induce Paddy to join us in this district." And probably there never was such a harvest as that of 1859, to which he then referred, for the difficulty of procuring harvest-men; nor was there ever before such a harvest (and this

adds force to the illustration thus given of the scarcity of labourers) for the quantity of grain cut down by machinery.

But let me state in figures what the actual rise has been in the value of farm labour.

In the autumn of 1849, I applied through the correspondents of the *Agricultural Gazette* for information on this subject, and from most of the English counties and many of the Scottish ones I obtained answers to printed questions, as to what is the present wage of able-bodied men, what is their weekly wage at harvest time, what is the ordinary daily wage of women in the field; what is the cost of mowing clover, of mowing meadow grass, of mowing barley, of harvesting a good ordinary crop of wheat; what is the ordinary rent of cottages, and so on. Nineteen years after this, *i.e.* within the past few months, I have done the same thing again, and have been told the rate of wages by upwards of 100 gentlemen residing in twelve Scottish, thirty-five English, and several Irish counties. There is thus the opportunity of making a very fair comparison of wages at a sufficient interval of time.

Let me first quote a few instances, taking the weekly wage of an ordinary able-bodied man as the criterion.

In Aberdeenshire, Mr. M'Donald, of Huntly, reported the wages of ploughmen in 1849 to be £16 a-year with board and lodging; they are now £22 to £24 with board and lodging. Mr. Bell, of Ferryden Farm, Forfarshire, formerly reported the ordinary weekly wages of an able-bodied man at 10s.; he puts it now at 12s. in winter, and 15s. in summer. Similarly, Fifeshire wages were 10s.; they are now 14s. In East Lothian the wages were 10s. a week, or 10s. with coals hauled free; latterly they are valued at 12s. to 15s., &c. In Mid-Lothian Mr. Melvin reported the annual wages of the married ploughmen at 910 lbs. of oatmeal, twelve cwt. of potatoes, two meals daily during harvest time, the hauling of four tons of coal, and £17 in money; he has since reported them at 1,050 lbs. of oatmeal, eight cwt. of potatoes, four weeks of harvest food, coals carted, house rent free, and £21 in money. Go now to the south of Scotland, and in Wigtonshire Mr. Caird reported wages nineteen years ago at 9s. a week; they are now put at £13 to £15 a year, with 120 to 130 imperial stones of oatmeal, four tons of coals, two to three bushels of potatoes planted on the master's manure, and house and garden free. A woman's daily wage was 8d., it is 10d. to 1s.

In Northumberland, wages, according to Mr. Grey of Dilston,

were 12s. weekly, with cottage and garden, and carriage of coals free; they now are 15s. with house and garden free; and Mr. Dods, of Hexham, gives to good ordinary labourers 16s. a week, besides six bushels of wheat, four bushels of barley, eighty stones of potatoes, land to plant ten stones of potatoes (about one-tenth of acre), with free house, garden, and coals carted. Mr. Drewry's wages at Holker, North Lancashire, were 13s. 6d.; ten years later they were 15s. to 16s. 6d. Mr. Evans, of Wigan, in South Lancashire, reported wages to be 12s. a week; Mr. Twining, in the same neighbourhood, afterwards reported them at 14s. From Lincolnshire I had four reports of the wages of able-bodied men, and they ran thus:—10s., 9s. to 10s., 11s. to 12s., and 9s. to 10s. I had four reports from the same employers in 1859, and they ran thus:—12s., 12s., 12s., 10s. to 12s.; and in 1868 two correspondents have reported them as 9s. weekly, with board wages, or 15s. a week without board.

Mr. Spencer, of Knossington, Leicestershire, told me nineteen years ago that 8s. to 10s. were the wages of the able-bodied men, and he put them eleven years later at 11s. to 12s. Take, now, the case of Norfolk: Mr. Cubitt, of North Walsham, nineteen years ago put the wages at 7s. to 8s., and the carters 1s. to 2s. extra; in 1860 they were 9s., and the carters 10s. 6d. In Northamptonshire, Mr. Grey, of Courteen Hall, Northampton, reported 8s. and 9s. as ordinary wages; he put them, eleven years later, at 12s. weekly. In Warwickshire, Mr. Burbury, of Kenilworth, who reported 8s. to 9s. weekly in 1849, reported 11s. in 1859, and 14s. in 1868. In Worcestershire Mr. Hudson of Pershore, who named 8s. formerly, said, nine years ago, 10s., or 9s. with two quarts of beer a day, were ordinary weekly wages, and now they are reported at 13s. to 16s. in the same locality.

In Oxfordshire, Mr. Druce, of Eynsham, stated 8s. weekly, the carters and the shepherds having cottages rent free in addition; wages in 1859 were 10s. to 12s., ploughmen and shepherds from 12s. to 15s. with cottages.

In Wiltshire, the worst paid county in the kingdom, wages were, some nineteen years ago, 6s. to 7s. a week for ordinary labourers; they were 8s. a week in 1859; and now they are 11s. and 12s. weekly.

In Kent they were 9s. and 10s., and again 11s. to 12s., now 16s. From Sussex I had three reports formerly 8s. to 10s., 10s., and 10s.; and I had three reports afterwards, 11s., 11s., and 12s. I have two reports now, 14s. and 15s.

From Dorsetshire I had five reports, averaging 7s. and 8s. a week, with cider or beer, and with cottage free "in some cases." I have two reports in 1868, the one names 9s., and the other says the payments make the money equal to 12s. weekly.

In Devonshire the wages were 8s. to 10s., and now 11s. to 12s. In Cornwall they were 8s. to 9s., and now 12s. In 1868 the wages of an able-bodied ploughman are declared as equal to 19s. a week.

All this proves, then, that the labouring force in agriculture is better paid than it used to be, and that the enormous extension of machinery and of steam power lately has not been to the injury of the farm labourer.

Instead, however, of quoting a succession of instances I will give, in as condensed a form as possible, the information I have received of the present value of agricultural labour. (See pages 77—81). When more than one return for the same county are given they are from different districts. The figures in the several columns are to be read in connection with the information given in foot notes (pages 80, 81) to which the index figures refer. The last column, K, of the table will be read with interest as indicating the general rent of the labourers' cottages in the several districts.

The reader must be left to himself to compare and contrast the condition of different localities, as regards the state of the labour market, by a comparison of the figures in the following table. It is plain that wages depend on the relation between the number of the resident labourers and the quantity of the employment for them. In some parts of Wiltshire they may be only 9s. or 10s. a week, while in other parts of the island they are nearly twice as much, and it is of course of the greatest importance to let these discrepancies be as widely known as possible.

It has been urged that it is more economical to pay liberal wages; and employers have said that they cannot *afford* to employ men for less than half-a-crown a day. It is declared that when we compare steam, and horse, and hand power together, the powers in question are not the engine, horse, and man, but the food which each consumes; and their relative economy therefore depends on their being fed properly and well. That the high-waged, well-fed labourer is really a cheaper source of power than the poor and half-starved man is no doubt true, and the only pity is that labourers have been so tied to parishes that wages do not naturally become more uniform in the country.

But the fact is that farmers have no choice of this particular "machine." They *cannot*, if they would, employ only a few, and "feed" them well. Those in any parish have to maintain all in that parish, either in the field or in the workhouse, and in some populous parts if they were to be "fed in order to their efficiency," they would eat up the whole produce of the land. It is plain that labouring men cannot be considered and cannot be treated by their employers as machines to be "fed," in order to obtain as large a "duty" from them as possible. It is upon their acquiring independence and manliness enough to seek for themselves the best circumstances of the country that the prospects of labourers in dense as well as scanty populations depend. Wages are the natural result of the relation of the labouring population to the labour offered them: and being bound to maintain that population, whether we employ them or not, it is probable that the rate of payment which naturally arises out of the circumstances is the best possible for all parties under those circumstances.

20. Mode of Hiring and Paying Labourers.—Besides the amount of wages there is the mode of paying them, which greatly affects the character and position of the labourer. It may be (1), partly in money, but with an immense variety of perquisites; it may be (2), partly in board and lodging in the house; it may be (3), in money solely. These three include, I believe, all the various systems of payment adopted.

1. Of the first I give two instances from the extremes of the island, Forfarshire and Dorsetshire. A Forfarshire correspondent writes to me as follows:—

"Our ploughmen receive per annum £18 to £20 in money, 6½ bolls oatmeal (140 lbs. a boll); 1½, Scotch, pint warm milk (3d. a pint during summer six months, 1 pint in winter ditto); 15 cwt. potatoes, and house and garden at say £3. This for a married ploughman. Unmarried: £20 and £22; one pint of warm milk daily all the year; 6½ bolls of meal, and fire and lodging in a bothy. At hay and corn harvest they get two bottles of beer daily, and bread and beer while leading to the stackyard. Married men get all their fuel driven by their masters."

I value those wages at 14s. to 15s. weekly. The daily workers, when getting something like steady work, have 12s. a week in winter, and 15s. in summer, with no beer or other allowance.

THE VALUE OF AGRICULTURAL LABOUR, 1868.

Column A gives the present weekly or annua wages of able-bodied ploughmen. Column B gives the wages of shepherds. Column C gives ordinary wages of common labourers, either weekly or daily. Column D gives the ordinary wages of women working in the field. Columns E and F give the wages of men and women respectively in harvest time—by week, day, or month. Columns G H I give the price per acre of cutting and tying wheat, and of cutting clover and mowing meadow-grass respectively. Column K gives the rent of labourers' cottages. The first column in the page gives the county. The information is in every case from gentlemen farming in the several counties.

COUNTIES.	No.	A	B	C	D	E	F	G	H	I	K
ABERDEEN	1	22*l.* to 24*l.*, with victuals.	20*l.* to 22*l.*, with victuals.	13*s.* to 16*s.*	8*l.* to 13*l.*, with vit'ls.	3*l.* to 4*l.*,* with vit'ls.	3*l.* to 3*l.* 5*s.*, with victuals.	......	......	......	2*l.*
PERTH	2	18*l.* to 20*l.*[1]	......	13*s.* to 16*s.*	1*s.*	20*s.* to 25*s.**	2*s.* 6*d.* to 2*s.* 9*d.*	10*s.* to 12*s.*	3*s.* to 4*s.*	......	2*l.* to 3*l.*
FIFE	3	14*s.*	14*s.*	13*s.*	1*s.*	3*s.* with victuals.	2*s.* 3*d.*, with victuals.	......	......	......	2*l.* 2*s.*
STIRLING	4	22*l.* to 28*l.* and board.	18*l.* to 25*l.*[2]	2*s.* 6*d.* to 3*s.*	1*s.* 3*d.* to 1*s.* 6*d.*	4*s.* 6*d.* to 5*s.*	2*s.* to 2*s.* 6*d.*	12*s.* to 16*s.*	3*s.* to 3*s.* 6*d.*	4*s.* to 4*s.* 6*d.*	2*l.* to 4*l.*
AYR	5	Engaged yearly.[4]	......[4](a)	2*s.* to 2*s.* 6*d.*	11*d.*	15*s.* and board.	2*s.* to 2*s.* 4*d.* a day.	10*s.* to 12*s.*	4*s.*	4*s.*	50*s.* to 60*s.*
WIGTON	6	13*l.* to 15*l.*[5]	13*l.* to 15*l.*[5]	2*s.*	9*d.* to 1*s.*	3*l.* with victuals.	......	10*s.*	3*s.*	4*s.*	2*l.* to 3*l.*
NORTHUMBERLAND	7	17*s.*	15*s.*	14*s.*	1*s.*	17*s.* 9*d.*	7*s.* 6*d.*	17*s.* to 18*s.*	4*s.* 6*d.*	4*s.* 6*d.*	1*s.* to 2*s.* 6*d.*
	8	15*s.*[6]	18*s.* to 25*s.*	15*s.* & 16*s.*	1*s.*	4*s.**	2*s.* to 3*s.*	All by machine.	All by machine.	All by machine.	Rent-free.
	9	16*s.* to 18*s.*[7]	12*s.* 6*d.*[8]	2*s.* 9*d.* to 3*s.* 6*d.*	1*s.*	24*s.* to 28*s.*	12*s.* to 15*s.*	10*s.* to 15*s.*	3*s.* to 5*s.*	3*s.* to 6*s.*	2*l.* to 5*l.*
YORK	10	14*s.* and overw'k paid.	15*s.*[9]	14*s.*	5*s.*	2*l.* extra.*	1*s.* 6*d.*	All by machine.	All by machine.	All by machine.	3*l.* to 6*l.*
	11	8*l.* to 18*l.*, with lodging and rations.	13*s.* 6*d.*	12*s.* to 13*s.*	9*d.*	21*s.* and rations.*	......	......	4*s.*	4*s.*	3*l.* 10*s.* to 4*l.*
LINCOLN	12	9*s.* weekly, board wages.	12*s.* to 14*s.*[10]	13*s.* 6*d.* to 15*s.*	1*s.* to 1*s.* 2*d.*	......	......	14*s.* to 16*s.*	3*s.* to 4s.	......	2*s.* to 2*s.* 6*d.*
	13	15*s.*	48*l.* per year.	15*s.*	1*s.*	20*s.*	......	10*s.* to 12*s.*	2*s.* 6*d.*	2*s.* to 3*s.* 6*d.*	4*l.* to 5*l.*

Counties.	No.	A	B	C	D	E	F	G	H	I	K
NORTH LINCOLN	14	13*s.*	13*s.*	13*s.*	6*s.* 6*d.*	21*s.**	......	10*s.* to 18*s.*	2*s.* 6*d.* to 3*s.* 6*d.*	3*s.* 6*d.* to 6*s.*	4*l.* to 5*l.*
SOUTH LINCOLN	15	16*s.*[10](a)	16*s.*	2*s.* 6*d.*	1*s.* 3*d.*	Doubled.	Doubled.	10*s.* to 18*s.*	3*s.* to 3*s.* 6*d.*	4*s.* to 5*s.*	3*l.* to 5*l.*
LINCOLN	16	10*l.* to 15*l.* and board.	18*s.* to 19*s.*	2*s.* 6*d.*	1*s.*	5*l.* with board.*	15*s.*	10*s.*	3*s.* 6*d.*	3*s.* 6*d.* to 5*s.*	5*l.* 5*s.* and wood of land.
LANCASHIRE ...	17	16*s.* 6*d.* to 18*s.*	18*s.* to 21*s.*	16*s.* 6*d.* to 18*s.*	9*s.*	18*s.**	12*s.*	6*s.*[11a]	6*s.*[11a]	......	1*s.* to 1*s.* 3*d.*
CHESHIRE... ...	18	14*s.*	......	12*s.*	......	18*s.* to 20*s.*	......	15*s.* to 20*s.*	3*s.*	3*s.* 6*d.*	4*l.*
	19	15*s.* to 16*s.*	......	15*s.* to 18*s.*	1*s.* 2*d.* to 1*s.* 4*d.*	20*s.*	1*s.* 6*d.*	10*s.* to 14*s.*	3*s.* 6*d.* to 4*s.*	4*s.* 6*d.* to 5*s.*	5*l.* to 10*l.*
NOTTS	20	5*l.* to 20*l.*, with rations.	15*s.* to 20*s.*	15*s.*†	1*s.*	5 weeks' rations.	......	5*s.* to 12*s.* 8*s.* to 20*s.*	2*s.* 6*d.* to 3*s.* 6*d.*	3*s.* to 4*s.*	2*l.* to 4*l.*
WARWICK	21	13*s.*	12*s.*	11*s.* & 12*s.*	8*d.*	Doubled.	Doubled.	10*s.* to 15*s.*	2*s.* 6*d.*	3*s.*	52*s.* to 3*l.*
	22	14*s.*	14*s.*	13*s.*†	......	18*s.* to 22*s.*	......	10*s.* to 16*s.*	3*s.* to 3*s.* 6*d.*	......	50*s.* to 5*l.*
HEREFORD ...	23	10*s.*[11]	11*s.*[12]	10*s.*	9*d.* per 8 hours.	2*s.* 6*d.* to 3*s.* 6d.	1*s.*[13]	Cut by machine.	Cut by machine.	Cut by machine.	50*s.* to 5*l.*
HUNTINGDON ...	24	14*s.*	14*s.*	12*s.*	9*d.*	25*s.*	9*s.*	8*s.* 6*d.* to 10*s.*	2*s.* 6*d.* to 3*s.*	3*s.* 6*d.* to 4*s.* 6*d.*	50*s.* to 4*l.* 10*s.*
BEDFORD	25	14*s.*[14]	14*s.*[15]	2*s.*†	......	4*l.* 16*s.*	......	10*s.* to 14*s.*	2*s.* 6*d.* to 3*s.* 6*d.*[16]	2*s.* 6*d.* to 3*s.* 6*d.*[16]	2*l.* to 3*l.*
OXFORD	26	12*s.* to 14*s.*[18]	12*s.* to 15*s.*[18]	12*s.* to 14*s.*	4*s.* 6*d.* to 5*s.* 6*d.*	......*	......	9*s.* to 16*s.*	2*s.* 6*d.* to 3*s.* 6*d.*	3*s.* 6*d.* to 4*s.* 6*d.*	2*l.* 10*s.* to 4*l.* 10*s.*
	26½	14*s.* to 15*s.*	16*s.* to 17*s.*	11*s.*, and piecework.	8*d.* to 1*s.*	3*s.* 4*d.*	1*s.* 6*d.*	10*s.*	3*s.*	4*s.*	1*s.* 6*d.*
	27	13*s.*	13*s.*[17]	11*s.*	1*s.*	18*s.*	......	11*s.* to 15*s.*	3*s.*	3*s.* 6*d.*	1*s.*
WORCESTER ...	28	13*s.* to 14*s.*	14*s.*	11*s.*†	4*s.* 6*d.*	15*s.* to 18*s.*	6*s.*	10*s.* to 15*s.*	3*s.* to 3*s.* 6*d.*	3*s.* to 3*s.* 6*d.*	4*l.*
	29	12*s.* to 15*s.*	......	12*s.* to 14*s.*	5*s.* to 6*s.*	Doubled.	Doubled.	10*s.* to 15*s.*	Machine cut.	2*s.* 6*d.* to 3*s.* 6*d.*	1*s.* to 1*s.* 6*d.*
GLOUCESTER ...	30	16*s.*[18]	18*s.*[19]	10*s.* and beer.	8*s.* to 10*s.*	......	......	10*s.* to 12*s.*	2*s.* 4*d.* to 2*s.* 10*d.*	3*s.* 2*d.* to 3*s.* 6*d.*	2*l.* 12*s.* to 3*l.*
	31	13*s.*[23]	12*s.*	12*s.*	5*s.*	15*s.*	6*s.* 6*d.*	7*s.* to 12*s.*	3*s.* 6*d.*	4*s.*	1*s.* to 2*s.*

	32	13s. to 14s.	14s. to 18s.	11s.	8d.	12s. to 14s.*	10d. to 1s.	10s. to 14s.	2s. 6d. to 3s. 6d.	2s. 6d. to 3s.	1s.
	33	10s. to 12s.	12s.[20]	10s. to 11s.	10d.	......	......	5s.[11a]	2s. 6d.	3s. 6d. to 4s.	2l. to 4l.
BUCKS	34	12s.	12s.	10s. to 11s.	8d. to 10d.	16s. and beer.	1s.	?	2s. 6d.	4s.	3l.
BERKS	35	12s.[21]	12s.[22]	11s. to 12s.	9d.	16s. to 18s.*	1s. to 1s. 2d.	11s. to 12s.	3s 6d.	4s. to 4s. 6d.	2l. to 3l.
	36	10s. to 17s.	12s. to 17s.	11s.	8d. & 10d.	12s.	10d. to 1s. and beer.	10s. to 11s.	2s. 6d.	3s. 6d. to 4s. 6d.	1s. to 2s.
	37	14s.[22a]	14s. and 40s.	13s.	10d.	3s.*	1s.	10s. to 16s.	4s. to 4s. 6d.	4s. 6d. to 5s.	4l.
NORFOLK	38	14s. 6d.[23]	......	2s. to 2s. 3d.	9d. to 1s.	6l. 10s.*	......	8s. to 14s.	2s. 6d. to 3s. 6d.	3s. 6d. to 5s.	3l. 10s.
SUFFOLK	39	13s.	16s. to 20s.	12s.	4s.	7l.*	......	?	2s. 9d. to 3s. 6d.	2s. 9d. to 3s. 6d.	3l. to 4l.
	40	12s.	13s. to 15s.	......	......	Double pay.	Double pay.	......	......	......	2l. 10s. to 4l. 10s.
	41	42l.	55l.	37l. 8s. 10d.	......	7l. 2s. 6d.*	......	8s. to 14s.	3s. to 4s. 6d.	3s. to 5s.	2l. 10s.
ESSEX	42	14s.[24]	14s.[23]	15s.	8s.	7l.	......	10s. to 15s.	5s. to 6s.	5s.	2s. to 3s.
	43	14s. 6d.	15s.[25]	13s.	9d.	7l. 4s. per month.	24s.	10s.	4s.	4s. 8d.	4l. 4s.
	44	11s.	12s. to 13s.[26]	10s. to 11s.†	......	4l. to 5l.	......	7s. 6d. to 12s.	2s. 9d. to 3s. 6d.	2s. 9d. to 3s. 6d.	55s. to 70s.
	45	16s.	16s.	2s. 2d.†	1s.	5l. to 6l.	2s. 6d.	10s. to 20s.	2s. 6d. to 5s.	4s. to 8s.	2s. to 3s.
MIDDLESEX ...	46	15s.	16s.	13s. to 18s.	6s.	Paid over-hours.*	Paid over-hours.	14s. to 20s.	5s. to 7s. 6d.	5s. to 7s.	6l. to 8l.
SURREY	47	15s.	15s. to 17s.	13s.	6s.	3s. and overtime.*	......	10s. to 12s.	3s. to 4s.	4s. to 5s.	2s. to 2s. 6d.
	48	13s.[27]	14s.[32]	2s. 6d. to 3s.	1s. to 1s. 4d.	3s. 6d. to 4s.	1s. 6d. to 2s.	10s. to 15s.	4s. to 5s.	6s. to 7s.	Rent free.
WILTS	49	12s. & many perquisites.	About the same.	10s.†	8d.	12s. to 20s.	......	10s. to 12s.	2s. 6d. to 3s.	3s. to 3s. 6d.	30s. to 50s.
	50	12s.[28]	36l. to 39l.	10s. to 11s.	8d. to 1s.	2s. 6d. and drink.	1s.	9s. to 12s.	2s. to 3s.	2s. 6d. to 3s. 6d.	9d. to 1s. 6d.
	51	11s.[29]	11s. and 5l.	10s.†	4s.	2s.	1s.	10s. to 14s.	2s. 3d to 2s. 6d.	3s. to 4s.	2l. 10s. to 3l. 3s.
KENT	52	16s.[30]	15s. & extra for lambing.	15s.	......	Double.	Double.	12s. to 18s.	4s. 6d. to 5s. 6d.	4s. to 4s. 6d.	Free to ploughmen

Counties.	No.	A	B	C	D	E	F	G	H	I	K
SUSSEX	53	14s. 6d. to 16s.[31]	15s. to 18s., & 20s. to 40s. gratuities.	13s.	......	2s. 6d. to 3s. 6d.*	1s. 6d.	11s. to 15s.	3s. 3d.	3s. 9d. to 4s. 6d.	1s. 6d.
	54	14s. to 15s.	15s. and house.	13s. to 14s.	......	21s.*	......	12s. to 15s.	3s. 6d.	4s. 6d. to 5s.	2s.
WEST SUSSEX ...	55	15s.[32]	15s.	2s.	8d.	3s. 6d. and 3 quarts.	......	10s. to 15s.	3s. 6d. to 4s. and 2 quarts.	3s. 6d. and 2 quarts.	1s. to 2s. 6d.
HANTS	56	12s.	14s.	12s.	5s.	Man and wife, 36s.*	Man and wife, 36s.	10s. to 12s.	3s.	3s. 6d. to 4s.	2s.
NORTH HANTS...	57	12s. and 2l. to 5l.	12s. and 2l. to 6l.	12s.	9d.	3s.	......	10s. to 12s.	3s. 6d. to 4s. 6d.	4s. to 5s.	2l. 10s. to 3l. 10s.
DORSET	58	9s.[33]	9s.	8s.†	4s. 6d.	12s.	6s.	15s. per week.	15s. per week.	15s. per week.	Cottages are free.
DEVON	59	12s., 3 pints of cider.	15s. & many perquisites.	12s.†	......	3s. 6d.	......	Cut by machine.	Cut by machine.	Cut by machine.	1s. to 1s. 6d.
	60	10s.[34]	12s. to 14s.	2s. & 1s. 8d.	8d. to 10d.	3s. 4d. with beer.	10d. to 1s. 2d. and board.	6s. to 8s. & 1 gallon.	2s. 3d. to 2s. 6d.	3s. 3d. to 3s. 6d.	2l. 12s. to 3l. 5s.
CORNWALL ...	61	12s.	12s. and 3l. per year.	10s. to 12s., and Wheat at 7s.	9d.	Meat and drink.	Meat and drink.	8s. to 10s.	2s. 6d.	3s. 6d.	3l. 10s.
CAERMARTHEN	62	12s. to 15s.	......	12s. to 13s.	1s.	As at other times.	As at other times.	......	3s.	3s. 6d.	3l. to 4l.

The following Notes are supplementary to the information given in the several instances quoted in the foregoing pages. They are referred to by means of the index figures which here distinguish them.

1 With $6\frac{1}{2}$ bolls (of 140 lb.) oatmeal, and 1 ton potatoes; 3 to 4 imperial pints milk a day; cottage and garden free. Unmarried men, money and meal same. Coals and house provided.

2 Head shepherds have house and garden, cow keep, and $6\frac{1}{2}$ bolls meal; young shepherds get their bed and board in the house.

3 Head married ploughmen, $6\frac{1}{2}$ bolls meal, 4 bolls potatoes, $\frac{1}{2}$ gallon sweet milk daily, free house and garden; coals carted. Single ploughmen lodge and get their food in the house.

4 With 5 to 6 loads oatmeal; free house and garden; coals carted free, &c. Equal to an annual wage of about £36.

4(a) The same as ploughmen, with, sometimes, cow keep.

5 120 to 130 imperial stones of oatmeal, 4 tons of coals, 2 to 3 bushels of potatoes planted on master's manure; all the manure they make planted with potatoes; house and garden; per annum. Shepherds about the same.

5(a) With the hauling of 4 tons of coals.

6 House rent free, and 400 yards of potatoes, and coals carted.

7 From 4 to 12 bushels of wheat, a few bushels of barley, 60 to 100 stones of potatoes, and free house. I pay my own men 16s. per week, 6 bushels of wheat, 4 bushels of barley, 80 stones of potatoes, land to plant 10 stones of potatoes (about one-tenth of an acre), with free house, garden, and coals carted.

8 Perquisites as ploughman, and six ewes and four hogs kept.

9 Cottage and garden rent free, a ton of coals, and 18 gallons of ale in the lambing season, and £2 extra wages in harvest, besides other small perquisites.

10 Beer in harvest, or £1 instead. Keeps a pig; if not, is allowed 15 to 20 stones of pork. Has beer or money for delivering corn, hay-carting, &c. Pays rent for house and garden. Under horse-keepers and ploughboys, 11s. to 14s. per week. Beer or money.

10(a) Cottage and garden free; worth to let 2s. 6d. per week. From £3 to £3 10s. extra pay for harvest, or its equivalent in fresh pork; 9 to 12 bushels of potatoes, or land prepared to plant.

11 £1 per year, 2s. 6d. per week in cider, five-roomed cottage, with large garden, rent free, and allotment of potato ground in the field, and coals hauled.

11(a) With loan of machine.

12 £2 per year, cider, cottage, and other perquisites as ploughman.

13 With cider and food on carting days.

14 Paid for overtime after six at night. He has the same in harvest as other men, with an allowance for Sundays. He has also "journey" money, besides beer for drilling.

15 With, in some instances, house and garden free. An allowance is made for each lamb, generally 2s. 6d. per score. The shearing is done by the shepherds at 1s. per score, besides day's pay. He also receives the same in harvest as other men, with an allowance for Sundays.

16 Ale is given for threshing, drilling, shearing, and other operations too numerous to mention. In hay time the men get from four to five pints per day; in harvest from four to seven pints. The beer costs the farmer for each man per week from 1s. 6d. to 2s., taking the year through.

17 Extra £2 for the lambing season, £2 for shearing sheep, £2 for hay and harvest.

18 Including house-rent, beer, and sundry perquisites.

19 With house (£3), £1 for lambing, 1s. 6d. per score for shearing, and 6d. a day beer-money in harvest.

20 £1 for lambing, 6d. for every double couple, 2s. 6d. per score for clipping sheep, 6d. per score for all sheep taken to market and cottage.

21 Table beer, £3 at Michaelmas, 1s. for every load of corn drawn out, and house rent.

22 House rent, £3 at Michaelmas, and 1s. a head for every double couple bred up.

22(a) £1 10s. to £2 at Michaelmas.

23 Harvest-money and cottage rent free.

24 With cottage, and £7 for the harvest month.

25 4s. a week for beer during six weeks' lambing time; £1 per 100 lambs. No harvest wages.

26 £1, with one or two pints of ale per day, in lambing season. 1s. per head for all lambs reared more than number of ewes set, and paid by the score for shearing.

27 With free cottage and garden, valued at 2s. to 3s. per week. Wet time paid for; and in case of a month's sickness no deduction made.

28 Extras: £2 for harvest, 1s. per load for delivering the corn to the miller, &c., and cartage of fagots and manure; making a total of £38 to £39 per year, besides drink.

29 With £3 for harvest, house and garden rent free, and 1s. or 1s. 6d. when out with corn. Under men, 6s. to 9s. per week and £1 at Michaelmas.

30 Our ploughmen are mostly single men, hired by the year; wages, £12 to £14, with board and lodgings.

31 And £1 to £1 10s. in harvest.

32 Good cottage and garden free.

33 There is some peculiarity in the amount of wages paid in this locality; the regular labourers on the farm have their cottages and gardens free, and wheat (either in proportion to their families or the number of workers) at 5s. per bushel. The shepherds and carters have, in addition, potato land, also free. Changes are seldom made—men working for one master or on one farm all their lives. Cottage accommodation indifferent, education not first-rate.

34 Cottage free, or the same wages with firewood found; coals drawn home, potatoes ditto, manure drawn, and other assistance given in cultivation of their allotment ground. Single men, who board and lodge in farmhouse, have in money wages £8 to £10 or £12 a year.

* With beer or cider daily throughout the year.

† With beer or cider in harvest time only.

In Dorsetshire, Mr. Saunders, of Watercomb Farm, Dorchester, writes to me as follows:—

"In answer to your inquiry respecting the wages of the labourers of this part, I will give you an account of what I pay my agricultural labourers of different callings. They all live on the farm near their work, where it is convenient for most of them to go in to dinner every day. I have eighteen cottages, for which I never receive any rent, as my men all live rent free, and most of them have good gardens, besides other potato land free. It is a very great accommodation to labourers to reside near their work; it is quite worth 1s. per week to a man not to have to travel a mile to his work morning and evening: and all have their regular pay, wet or dry weather; there is no loss of time except they are working by piece work, which most of them get in their turn during the year, when they generally earn from 10s. to 15s. per week, according to circumstances. And all this is in addition to their yearly privileges, which, as many of my labourers have said to me at different times, 'is nearly half our living,' referring to a cottage garden, potato land, and the privilege of having grist over that of buying bread of a baker, as I regulate the grist by allowing a peck a head to the family of workers in a house. I think our system is nearly equal to other counties, where they give nearly double the wages, but no house nor other privileges, nor pay for wet days. In this county we agree for a family at a certain sum, from the 6th of April to the 6th of April in the following year; and some of my men have continued on my farm with me for more than thirty years without change. The following is about the general run of wages in our county:—

	£	s.	d.
House, good garden, worth to let, £4 a year	4	0	0
Weekly wages 8s. or 9s., and 30 perch of potato land ploughed in with their potatoes, often growing 15 sacks, now worth 10s. per sack, which, allowing the seed out, would be worth £5 ...	25	16	0
200 furze faggots, carried home free to the cottage	1	0	0
28 cwt. best coals, carried home at 1s. per cwt.—advantage worth at least	1	14	0
Extra for harvesting, cash £1, and 1 gallon of ale per day... ...	2	0	0
Every journey with team, 1s.; average one per week	2	12	0
Three quarts of ale per day at haymaking, for 8 weeks, at 9d. per gallon...	1	7	0
One bushel of wheat per week (more, if there be other workers in the family) at 5s., not much advantage now, say 6d. per week, but when dear, 3s.	1	5	0
The *ploughman's (carter's)* wages are thus about 15s. per week ...	£39	14	0

	£	s.	d.
My shepherd has the same as the horse-man, except that he earns about £3 extra for sheep which he shears, and he has 1s. per score for all lambs bred, which at about 600, is £1 10s.; and also 6d. for every ram let or sold, generally £2 10s. in all ...	7	0	0
Take from this the difference of carter's journey money, which is...	2	12	0
Leaving in favour of shepherd	4	8	0
Wages and perquisites as carter's account	39	14	0
Shepherd's wages weekly, 17s.	£44	2	0

"The common *labourer* receives 8s. per week, house, garden, potato land, 200 of furze, 15 cwt. of coals, grist, as I have before stated, at one peck per week for every one who works, great and small, some at 5s. per bushel, and some at 6s. per bushel; and most of my labourers have piece work at different times of the year when convenient. I consider, on an average, a good labourer's place with me is worth fully 12s. to 13s. per week."

This is a most elaborate scheme of payment, and certainly a very liberal one, though I do not value the items so high as Mr. Saunders does, making the yearly wage of his ploughmen as nearly as possible 14s. a week. I may add here, in illustration of the Dorsetshire method of paying wages, that at a meeting some time ago of the Blandford Farmers' Club, it was resolved that the wages of ordinary agricultural labourers then paid in the county amounted, taking perquisites into account, to at least 12s. a week, while for shepherds, carters, &c., 14s. or 15s. a week was a common payment.

2. Now, over large districts in England another system obtains, of which Mr. Manser, a tenant farmer at Dumpton, near Ramsgate, gives the following very interesting account:—

"Our ploughmen here are generally single and yearly servants, and are boarded and lodged by the farmer or by his bailiff. They are hired from the 11th of October to the 11th of October each year, and though they sometimes continue for several years with the same master, a fresh agreement takes place every year. They commence as lads at thirteen or fourteen years of age; their duties then are to drive the horses and attend to them in the stables, and we almost invariably find that the younger the boys go to service (as it is here termed) the better ploughmen and the better labourers they afterwards become. They begin at about £5 wages per annum, which is usually increased every year as their strength and ability increase, or as master and servant agree; the increase goes on at the rate of about £1 per year,

and our head horse-man or waggoner, gets from £12 to £14 per year. The cost of their board varies according to the price of provisions, and when they are boarded by a third party, it is generally paid partly in money and partly in kind; they always have meat three times a day, and cannot be boarded on an average at less than 8s. per week per head. In some few instances, however, where there are cottages near, married men are employed as ploughmen at wages of 14s. per week, and a cottage rent free; if they have to pay rent they are usually allowed about £5 extra for harvest, in addition to the 14s. per week. I find, on examining my labour account, that my best men, on an average of the year through, earn about 16s. per week, or a little over £40 a year. This includes harvest and hay-making, as well as lost time from weather or other causes, and is the man's earnings, independent of the rest of the family." He adds, "Our labourers pay about 2s. 6d. per week rent for their cottages, and for this many get but a miserable home. I know of nothing in the neighbourhood so disgraceful as the want of accommodation for labourers. They are (many of them) driven to reside in the worst parts of the towns, many of them in hovels, built or rather stuck up for the sole purpose of investment, without any regard to health, comfort, cleanliness, or morality. No garden is attached, or anything else to make a poor man's home comfortable; they are completely away from the eye of all who feel an interest in his welfare. The consequence I need not describe. There is every inducement for them to spend their spare time and hard earnings at the public-house or beer-shop; they have often from two to three miles to go in all weathers to their labour; they never know the luxury of a hot dinner or a meal with their families, except on a Sunday; the children run the streets in the worst parts of the town, and get early imbued in every wickedness. With no father near to correct them, how can it be otherwise? I do hope this subject will be pressed before the public on every favourable opportunity."

There are several local or provincial peculiarities in the relation of farmer and labourer which, though not exactly of the same class as that to which Mr. Manser's letter alludes, may be mentioned in the same paragraph with it, for in both there is part payment of wages in the form of board and lodging. I refer to the so-called "bondager" and "bothy" systems prevalent in the south-eastern and in the north-eastern counties of Scotland.

In the former, the married hind who occupies one of the farm cottages, is bound to provide for his master during the year, a woman worker, who thus becomes the "bondager," receiving 10d. to 1s. as may be agreed upon for every ordinary day's work she does, and 1s. 6d. more for every harvest day's work she does. This is a great burden on the man, for it imposes a lodger on him who may be a most undesirable inmate; and such women workers are able to obtain from £7 to £9 as yearly wages, along with their board and lodging, the expense of which, borne by him, is rarely met by the daily wages which the woman earns for him. And the system is not good so far as she is concerned either, for it places her in the position of a servant's servant, and removes her so far from direct relationship to the master of both, as to impair that interest in her well-being which he might otherwise both feel and exercise.

In the "bothy" system, on the other hand, the young men whom it concerns are directly the servants of the farmer—they are his unmarried ploughmen and labourers—and he provides a room or rooms (the so called bothy) in which they are lodged apart from the farmer's house, and in which they have their meals, which are in fact oftentimes prepared by themselves. Of course such an establishment may be so looked after by the master, as that it shall be a useful school to all its inmates—but this represents only the possibilities of the case—the probabilities of it, as of every other enforced departure from, or violation of, the family system natural to man, are far otherwise. The evils of the system arise out of the isolation of young men, the impossibility of any but clandestine association with the other sex, and the consequent liability of such intercourse to become licentious. And it is a fact which might have been expected under the circumstances, that there is a greater number of illegitimate births in proportion to the population where the system prevails than occurs elsewhere. The wages obtained by young men in the districts of the bothy system are stated in the table. The system itself has no doubt arisen out of the absence of sufficient cottage accommodation for the labourers of the district. The responsibility for the evils which have arisen out of it rests primarily, therefore, on the landowners of the locality.

In Lincolnshire and some other counties, Kent, for example, as Mr. Manser mentions just above, a system of boarding young labourers prevails; and on this subject a paper was read, some years ago, before the London Farmers' Club, by Mr.

Marshall, of Riseholme, Lincolnshire, whose experience was thus described :—

"In some of the southern and midland counties the custom prevails of hiring labourers by the year at a certain sum per week, which is regularly paid every Saturday night, a small deduction, say about 2s., being kept in hand to ensure the service till the end of the contract, the servant in all cases engaging to board and lodge himself at his own expense. This he usually does with the foreman on the farm, who undertakes to supply him with bread, meat, milk, and vegetables, at a fair market price. In addition to the cost of provision, 1s. 6d. per week is charged for lodging and cooking; no beer whatever is allowed, except during the time of hay and harvest, when four pints per day are commonly given. The greater portion of the servant's wages is thus absorbed (some being in debt) or spent in some less creditable manner, and the only accumulation he can boast of at the end of the year is that of the 2s. per week retained in his master's hands, which he will require for the purchase of clothes, shoes, &c., leaving little or nothing as a fund for the savings' bank. In some of the northern counties, and also in North Lincolnshire, with which I am more immediately connected, it is the custom to employ a large number of unmarried servant men and lads, who are regularly hired by the year, from Old May day till Old May day, at the various statutes held in the district for that purpose. At present wages vary from £5 for lads who can plough and go with horses, to £20 for head wagoners, who are also drill men, and stack during harvest. On a farm of 500 acres of turnip land it is customary here to work about fourteen horses, for which five farm servants, under the superintendence and control of a married foreman, are considered sufficient. The foreman, with whom these men reside, is, of course, a responsible person, and undertakes to provide them with everything that is requisite as far as board and lodging is concerned. He also sees that they do their duty during the week, and that they invariably go to church with him on a Sunday once at least. An ample house, and garden for vegetables, is provided rent free; £30 a year is in wages given to the foreman, who has also the produce of two cows for five, or one cow for three men; twenty-six stones of bacon (*i. e.* a fat pig weighing twenty-six stones) for himself, and twenty-six stones for each of his men; he has, further, forty stones of flour, twenty of best seconds for puddings and pies, and twenty best thirds for bread for each man, one

quarter of malt for himself and the harvest men, and one sack for each man servant (equivalent to one pint per day and four in harvest). He has five tons of coal for the year's consumption; he finds candles for the stables and chaff-house, when required; and has 1s. per day for all casual boarders, such as additional harvest men, blacksmiths, carpenters, &c., who work by the day, and have their board. The men have three meals per day. For breakfast hot bread and milk, and cold meat; for dinner hot meat, pies and puddings, vegetables, and one pint of ale; for supper hot meat, bread and milk, or pea soup. By this means they have always meat three times a day, milk twice, and beer once. They pay for their own washing, and are allowed an interlude of three or four days as a holiday at some fitting period during the year, which always expires on the 13th of May. I believe the quantity of bacon allowed is always consumed, but I believe the flour is a little above what is required. The ordinary consumption of a man, his wife, a servant maid, and five men, usually averages about thirty stones for each person per annum. The annual expenses of their board and wages may be set down as follows:—

	£	s.	d.
Foreman's wages	30	0	0
26 stones of bacon, at 7s.	9	2	0
1 quarter of malt	3	12	0
2 cows, at 3s. 6d. each per week	18	4	0
130 stones of bacon, for five men, at 7s.	45	10	0
200 stones of flour, at 2s.	20	0	0
5 sacks of malt, at 9s.	9	0	0
5 tons of coals, at 12s.	3	0	0
Wages:—2 wagoners, at £12	24	0	0
,, 2 middle men, at £10	20	0	0
,, 1 boy at £6	6	0	0
	£188	8	0

In addition to the above, the foreman's wife shares largely in the profits of this system, inasmuch as she has the butter and superfluous milk from two cows to dispose of, the privilege of raising poultry of every description, and gathering eggs. For these she receives a certain price per couple and per score, out of which she pays her maid servant, and retains the residue as her own perquisite in return for her vigilance and labour. Upon her good management very much depends the comfort and well-being of the whole establishment. These items amount to £188 8s. for six men, namely, one foreman and five farm servants, the yearly

average for each being £31 8s., or within a very trifling sum of 12s. per week. Now, if it be taken into consideration that the ordinary wages of a daily labourer in that district are 15s. per week, exclusive of a very considerable increase during harvest, I think it must in justice be conceded to me that I have, at least, pointed out to you not only a far cheaper, but in every other respect a far better plan; such a one, moreover, as may at any time be made available in any county or in any locality, and one that is equally advantageous to master and servant. It has, too, the acknowledged authority of one of the largest and best cultivated districts in England to confirm its practical utility, and to warrant its more general adoption."

Mr. Marshall's interesting account furnishes a very liberal and excellent plan of managing his men.

3. The third method of payment is by a weekly sum of money. The amounts given in the several districts of the country have been already stated: and the only remark to be made upon the system is that, whether the payment be weekly or fortnightly, it will be a great convenience to the recipients if they are paid on Thursday or Friday evening instead of Saturday. The marketing for their families can then be done with greater advantage to themselves; and there is, perhaps, less temptation to spend money at the beer-shop. As regards weekly labourers, also, care should be taken to pay wages justly; *i. e.*, according to the real worth of the men. Nothing more discourages effort, self-respect, and energy in men, than treating them alike, however different may be their value as labourers. Under this head, the alternative has to be considered of payment by the piece, and payment by the day or week. It seems plain that the former is the better plan whenever it can be adopted. A little experience will enable any one to determine the proper price per perch, or acre, hundred, ton, or bushel for the operation. The price should be fixed before the work is commenced, and whatever may be the wages earned per week under this agreement they should never be begrudged. On the other hand, if the wages earned be insufficient, it is better to make it up by letting the next job more liberally, rather than by a sum paid as a recompence for the loss, for this would tend to give the labourer hopes of wages to be earned otherwise than by industry. In either case the work should be carefully superintended throughout its performance, as it will demoralise the labourer as well as injure the master if a careless and imperfect performance be allowed. The prices to

be paid for various kinds of work will be found on reference to the index.

21. Piece-work Payments.—This subject requires, however, a more detailed consideration; and this it received in so able and satisfactory a manner by Mr. C. Howard, of Biddenham, near Bedford, at a meeting of the Central Farmers' Club, that I shall use his words on the subject.

"A farmer," he says, "is far from being so advantageously placed as the manufacturer in letting his work by the piece, inasmuch as it is impossible for all the work of the farm to be performed on that system; a great deal, such as the feeding and tending of stock, carrying corn to market, and many of the field operations, cannot be done otherwise than by the day. Again, the farmer has to contend with the elements; and, if ever so disposed to keep his men at piece-work, the weather frequently prevents him. Again, some farmers are situated, as I am myself, with a good and well-conducted set of men, whom he is disposed to keep all the year through; and at certain seasons, when work is not very plentiful, there is no inducement to the farmer to set his men to piece-work, which would have the effect of raising his weekly expenditure. Still I think the system might be advantageously extended; for I find upon farms where piece-work is generally adopted, the work of a farm is always in a more forward state than where the day system prevails; the men are better off, they are more active, and more skilful. It is a well-known fact in the commercial and manufacturing world that those trades have been the most successful, and have made the greatest progress, in which piece-work has been the rule; and I think this may be partly accounted for on the ground that the men feel an interest in facilitating the various operations upon which they are employed; the energies of their minds are also bent upon finding out easier and quicker methods of getting over their work. Put a set of men by the piece; at once a rivalry is felt as to who shall do the most work, or, to use their own words, be "best man." Piece-work, too, is the readiest way of making a difference between the good and indifferent labourer; and the plan adopted by many masters who wish it to be the rule, is to pay a comparatively low price by the day, in order to induce their men the more readily to take piece-work."

Mr. Howard proceeded to give the reports on the subject which he had received from correspondents in different parts of the country. In the northern part of England and in Scotland,

there is not much work done by the piece, in consequence of the practice of having yearly or half-yearly servants. In most of the counties of England, on the other hand, it is carried out to a considerable extent; the operations by the piece being hoeing of corn and root crops; filling and spreading manure; mowing grass and seeds; washing and shearing sheep; cutting, carting, stacking, and thatching of corn; laying and trimming hedges, ditching, draining; mangel pulling; turnip cleaning, heaping, and covering; cutting haulm, and threshing Lent corn. I have made particular inquiries as to the important subject of harvesting, in which great changes have been effected since the introduction of reaping machines. Mr. Howard's own practice is to let the whole of the cutting, carting, and thatching to a company of men for so much an acre. This plan is also adopted by his neighbour, Mr. Pike, of Stevington, who says:—

"I let my last harvest as follows: I agreed with seventeen of my own men to cut, cart, and stack the whole of my corn at 11s. per acre, with four pints of beer per day, to be cut close to the ground and all tied, viz., one hundred acres of wheat, sixty of barley, fourteen of oats, and sixty of beans. I agreed to find boys for carting and to horse-rake it; they tie and cart the draggings; the thatching is done at 1s. per acre. In former years I let the thatching by the square; that did not answer, as they made too many stacks, by not carrying them high enough in the walls. With regard to using the reaping-machine, they agreed to allow me 3s. per acre for the use of it and horses. By adopting the plan of letting the whole harvest, I had very little trouble with men or boys, for I find if they do not get on fast enough, they can get hands when I could not."

Reference will be made in the sequel to the cost of different agricultural operations, both when done by day-labourers and when paid for by the piece. The above statement has, in the meantime, been extracted from Mr. Howard's lecture, in illustration of the general superiority of the latter plan of payment whenever it can be adopted.

22. Relation of Master and Servant.—For all the various customs of payment there must, however, of course, be the general assent of the labourer, and the concurrence of both master and servant; and so long as a labourer agrees to take certain wages, there is no place for interference by any other person.

I will, however, say that a very short acquaintance with the

subject shows that every system which has been devised for paying labourers is liable to abuse. The payment of a stipulated sum of money for stipulated services to be rendered is, of any plan, the least so liable, and it ought as far as possible to be carried out. That system which gives food and accommodation is the best of all, when administered with kindness; for the extras are worth to the labourer much more than the sum at which they would be valued to him in a money payment; but it is more liable to abuse than the simple money payment. The abuse in this case affects the due reward of labour; as, for instance, the privilege of receiving wheat at 5s. a bushel may very easily be made no privilege at all. The payment, too, of all this household stuff as wages, is a thing which affects householders only, and the young men who are leaving us are those whom we want to keep. To do so, then, as Mr. Mein, a large employer of agricultural labour, tells us, we must just offer wages which will keep them—wages, too, according to the work they do. This, however, is not the whole truth of the matter. The relation of master and servant is mixed up in agriculture with much beside a mere bargain for the sale of services—with much that is personal; there is more scope for the development of kindly personal feeling between the two than there is in the case of any other class excepting household servants. Of course this personal feeling may show itself in that which is of higher value than money is capable of measuring. A young man will, notwithstanding lower wages, keep his place for the sake of advantages of greater value than the increased sum he might otherwise receive. His master takes an interest in him personally, showing it by helping forward his education, and by seeking ultimately a better position for him; and this is soon observed and thought of. But there is a reverse side to this picture, and just in proportion to the closeness of contact which the terms of service enforce between the two *may be* their recoil asunder as soon as they are once more free.

If there be a plan which would strengthen the bond between the two more than any other, one would imagine it to be the very common one in England of lodging the younger labourers in the farm-house, and giving them partial board as well as cash. But what is the ordinary experience on this point? In many an English country parish, Old Michaelmas Day sees an almost complete sweep of the young men and lads who have lived during the past year in the houses of their masters. The evening school

each winter presents a new array of faces—and the masters are for a while at least and necessarily as much strangers to their lads and many of their men, as if they paid their wages through a clerk, and had as little opportunity of personal acquaintance as a manufacturer with his hundreds of mechanics.

It is plain that it is not in the *system*, but in the administration of it, that merit and demerit lies, and that while sufficient wages (and that is just as much as labourers can get) are given, a personal interest in the labourer as a neighbour is what will bind him to his master.

If I had in a single sentence to describe the relation of master and servant in the agricultural world, it would be to assert that nowhere is it better and nowhere is it worse. The two are thrown closely together, and character is on both sides known, and therein lies the explanation; the two are never, as is unavoidably the case when one man pays 500—they are never indifferent to one another—they love, honour, and respect each other, or they distrust and hate: and while in the former case there is a noble scope for exerting a useful influence for their well-being over those who are employed, the latter, in the very closeness which is the condition of agricultural service, has scope enough for bringing forth its fruit.

The combination of sufficient wages with a greater scope for personal goodwill than any other trade affords, is what may, and often does, honourably distinguish agricultural labourers and employers amongst the multitude of English occupations.

Let me add one word more on this topic. The whole value of the expression to which this goodwill leads arises out of its origin in a personal feeling—it cannot be deputed without altogether losing its character. Anything like the transference of my personal duty and pleasure in such a thing to a public institution spoils the whole affair.

There are local and provincial societies long established in England for distinguishing the worthy among agricultural labourers by public testimony to their worth. If that worth had shown itself in public-spirited conduct, nothing could be more appropriate than a public acknowledgment of it. When it is, however, only personal and domestic worth (far more worthy, let us all admit it, than the other), nothing can be more grotesquely out of place.

These societies have, however, been established, and are supported by a real if unwise philanthropy, and I would not say one

word in discouragement of their object, however unwise may be their plan. Benevolent men have truly seen that the relationship of master and servant is but a part of the truth affecting them; and in carrying the superiority of the employer over his servant into a field where no superiority exists, they have read the commandment as if it were addressed to the former only; and as if it said of the latter: "Thou shalt be a father unto him." The system of rewards for good conduct, for long servitude, and for morality, is founded on a mistaken idea of this kind. It *is* a mistaken idea—let me repeat it. Along with the paternal relationship, with all its powers and responsibilities, wherever it really exists, God has implanted the natural love of the father as the safeguard of the child, and the docility and helplessness of the child as the counterpart justification of the father. Neither of these conditions applies to the relationship of master and servant. The commandment has been mis-read. It is really addressed to both alike, and it prescribes a perfectly mutual and equal duty in words addressed to each—"Thou shalt love thy *neighbour* as thyself."

This is the law which supplements the bare relationship of master and servant, and makes the operation of it perfect. But it is not for me to pursue the subject further, or to illustrate at any greater length to what it leads. I will only add that the more we encourage genuine individual manliness in labourers, with its efforts after real self-improvement in intelligence and skill, and its higher sense of individual responsibility, the more likely are we to attach the young men to us, and to obtain labour of the kind of which steam-power is rapidly proving the necessity. But this is not to be done either by taking all the difficulties of their position out of their way, or by offering rewards to them proper only to the qualities and condition of a child.

23. The condition of the Agricultural Labourer has of late occupied a good deal of public attention. The Rev. Canon Girdlestone, incumbent of the Parish of Halberton, in Devonshire, has attracted it, by his efforts to raise the condition of farm labourers in his neighbourhood, and in particular by the very considerable number of labourers with their families whom he has sent from that district of comparatively low wages, to other parts of the country where wages are higher.

The attention drawn to his proceedings resulted lately in a public meeting held in Willis's Rooms, St. James's Square; at which it was resolved, almost unanimously, (1) that in many parts of

the country, the condition of the agricultural labourer, as regards wages, house accommodation, and opportunities for acquiring information and manual skill, is such as demands serious and immediate attention. This was a proposition to which all were ready to assent, but when Mr. Girdlestone proceeded to found upon it (2) a proposal to encourage and assist the formation of agricultural labourers' unions, he was supported almost exclusively by political agitators, such as Messrs. Beales and Potter; and although it was resolved that these societies should be carefully guarded against all possibility of violent aggression, either on employers or fellow-workmen, and that their chief object should be to secure fair remuneration to labour in proportion to skill, ability, and industry, it was felt by a very considerable minority of the meeting that he was endeavouring to introduce a new and mischievous agency between agricultural employers and labourers.

The Conference was attended by many who might well claim to represent both classes—the Earls of Essex and of Lichfield, Lord Northbrook, Marquis Townshend, Mr. C. S. Read, M.P., Mr. Fawcett, M.P., Sir E. Lechmere, Bart., Mr. Ed. Beales, Mr. G. Potter, Professor Rogers, besides the Rev. Canon Girdlestone and others by whom the meeting had been organised.

The upshot was, that by a narrow majority the Rev. Canon Girdlestone succeeded at such a meeting in introducing the trades' union principle among agricultural labourers. It would be a very mischievous mistake; but the seed will not, we believe, find a congenial soil in the field where it is now for the first time planted. No doubt the first of the above resolutions states nothing but the truth. It would, however, have been also true if the words it uses had been applied to any other class of labourers—for in many places the condition of the mechanic also and of the day labourer in manufacturing and commercial industry is extremely unsatisfactory. And it was the knowledge that the trades' union principle had been for so many years in operation among them without beneficial effect—if, indeed, it has not rather tended to aggravate their misfortunes—that at this meeting, guided though it was by Messrs. Beales and Potter quite as much as by Canon Girdlestone, the second resolution, inaugurating labour unions in country districts, was adopted by a majority of only five.

It would, we believe, have been more serviceable to the agricultural labourer if the many benevolent men in our country districts could have united in a society which should have been devoted simply to the work which Canon Girdlestone has been

lately doing, so that thus there might have been spread throughout the country in every village a more perfect knowledge of the agricultural labour market. One speaker did, indeed, declare that to take the labourer from where he is badly paid, and place him where he is more wanted, would tend rather to reduce wages where they are high than to raise them where they are low. But it is plain that such a result is inevitable, and that the amount of wages in any district cannot be directly altered. The equalising of the demand for labour is the only help that, in the nature of things, can be offered.

It is plain that it is only indirectly that we can aim at the results desired, and the only immediate palliative possible for excessive local hardship appears to be migration to localities where labour is dearer, being scarcer. If Canon Girdlestone had called to his aid a local agency, by which a freer intercourse and intelligence might be opened up between labourers and employers all over the country, he would have benefited both classes, and thus have certainly secured a benefit for the one which needs it most. As it is, he asks for money wherewith to pay travelling agents who will do what in them lies to set employers and farm labourers at loggerheads all over the country. A committee has been constituted to appoint organising agents, who will be employed in forming the several local unions of agricultural labourers, and in directing and superintending their working; and those interested in the improvement of the condition of the agricultural labourer are requested to provide the funds for the payment of the salaries of these organising agents, and the other necessary expenses. We are persuaded that the money spent in this way, notwithstanding that these organising agents are to be instructed "to promote in all possible ways the improvement of the agricultural labourer," will be money not merely thrown away, but productive of injury to the class it is intended to benefit.

At the same meeting, Mr. Fawcett, M.P., moved and carried a resolution :—

"That in the opinion of this Conference the condition of agricultural labourers will continue to be depressed and unsatisfactory until their education is secured by compelling children under thirteen years of age to attend school so many hours a week." This is another subject which has engaged a good deal of attention lately, and on which attempts at legislation have been and no doubt will be made. It is impossible, within the limits of a little book, intended to be simply descriptive and instructive as

to the actual condition of farm labour, to state the arguments at length on which the discussion rests. Considering the slow progress of school work in country places, and the advantages which have arisen from a corresponding rule in manufacturing towns, it seems desirable that, up to a certain age, no children should be allowed employment in the field who cannot show a certificate of a certain attendance at school; and the age of nine or ten years is one which has received the assent of many Chambers of Agriculture before whom the subject has been discussed. I may refer those who are interested in the question to a lecture (1868) by the Rev. Prebendary Brereton, before the Barnstaple Farmers' Club, on "Earning and Learning;" to a paper, by Mr. Herman Biddell, read last March before the Framlingham Farmers' Club, on "the Employment of Women and Children in Agriculture;" also to a pamphlet on "the Education of the Agricultural Poor" (Chapman and Hall), being an address on this subject, before the Botley Farmers' Club, by Captain Maxse, R.N.

The Rev. Prebendary Brereton says that it is a mistake to call any class who maintain themselves "the poor." The poor are those of all classes who are struggling, unable to maintain themselves in their class. And it is the children of the agricultural labourer of whom Captain Maxse speaks in his pamphlet as the poor. Nevertheless, his opening sentences do, to some extent, justify its title; for he speaks almost immediately of the evidence which exists at every board meeting at the Union of the semi-pauperised condition in which too many of the class exist, so that "the steady mustering at the Union, after one fortnight's hard weather, is sufficient to illustrate the semi-pauperised, thriftless, and indigent condition in which they exist." The perusal of the three addresses I have named will put the reader in possession of almost all the facts and arguments necessary to guide his opinion on this subject. I think that the tone of Mr. Biddell's address is the one which will be most likely to commend itself to experienced men. He said:—"Farmers as a body do not always do the best by the little boys they have about them. The extension of the Factory Act will not make them a bit better in that respect, but a little thought and a good deal of attention might improve matters vastly. We are differently situated from those in trades and professions. If a boy goes to a farmer, and he puts him to plough for a year or two, he will make sad havoc with the drilling and horse-hoeing through his inexperience in laying a level stetch; but the moment he can do the thing as it should be done (having,

in the meantime, spoilt the mouths and tempers of half-a-dozen good horses), he immediately starts on his own account, and becomes the servant of the first man who will give him 1s. 6d. more than his old master. In trades, the master, by agreement, secures to himself some years of service after the boy had learned the rudiments of his business. It is not very encouraging for a man to take a boy, teach him to plough, and then, when he is of some use, see him start off for some other sphere, only to leave the plough-handle vacant for the next to try his hand on; but that is no reason why we should let the labourers' boy speak, move, and think at a pace 100 years behind the speed of any other mortal this side the Tweed. Let us impress on the boys that no such thoughtless answer as "don't know" and "can't" will be allowed; make them speak sharp the moment they are spoken to, answer the moment they are called, and run the moment they are wanted. Take care to have this done, and point at certain penalties in case of disobedience—not the ash stick, or the box on the ears—probably that has been tried at home; but give the boy to understand that unless he imbibes smartness he will be sent the first long errand on foot that turns up, or when the other boys are gone home he will have to stay at work half-an-hour alone; and recollect that a well-judged word of praise goes a long way with a being to whom such words are rare. Two bright penny pieces to a lad whose only assets are a pocket-knife, a whip-stick, and a copy of Watts's Hymns, are a wonderful inducement to do a job quickly and carefully. Mr. Biddell spoke from personal experience. He had a weakness for boys, and had nine on a farm of about 270 acres. On these he had practised the system he recommended; and if he had some full of mischief, some stupid, and others careless, if some were idle and others better disposed to work, if they were no better than boys differently treated, he knew they were brighter, more useful, quicker, and far more obliging than they were before he paid any attention to them. He did not believe they required to put wits into the heads of their rustics, so much as they wanted to make those wits work which they were already possessed of. A like attention paid to the morals and the manners of the boy, when under the control of the master, had a marked effect on the address and conduct of the lad. The habit of using bad language, cruelty, prevarication, and deceit should be shown in their true light, and on detection a master should seriously, firmly, but calmly, explain the consequences of such habits. The words of an earnest, dispassionate

man had a powerful influence for good on a lad to whom the oath and the ash stick were the common means used to impress new ideas on his mind. He strongly urged the importance of the personal influence on the part of the master; and, turning to education, while saying God forbid that he should raise a finger to retard the efforts of those who wished to extend to the meanest agricultural labourer the blessing of a knowledge how to write, he expressed his doubts whether the sanguine expectations indulged in by those who looked for a millennium of intelligence, elevation, and improvement by compulsory education, were not doomed to disappointment.

The following are abstracts of two Acts passed in the last session of Parliament, affecting agricultural labourers, for which place, therefore, should be found in these pages:—

"The Agricultural Gangs Act" came into operation January 1, 1868. No child under the age of eight is to be employed in a gang; nor females in the same gang with males, nor except under a female gangmaster, under a penalty of 20s. for each child or woman so employed. Gangmasters are not to act, except licensed. They are in no case to be keepers of public-houses. Licenses are to be granted by two or more justices for six months only. There are various penalties enacted for offences against this Act, which applies only to England.

The "Master and Servants Act" may apply to agricultural as well as other employments. It declares that wherever the employer or employed shall neglect to fulfil any contract of service, or wherever any dispute shall arise as to the rights or liabilities of either of the parties, or touching any misusage to the person or property of either of the parties, the party feeling aggrieved may lay a complaint in writing before a justice; and the justice is to have power to award damages against, or impose fines on either party, to be levied under penalty of imprisonment. The Act may last till the end of the next session of Parliament.

V. COST OF FARM OPERATIONS.

In this section of the book it is proposed to state or estimate the labour-cost of various farm operations and results, naming the authority for each, except in those cases where the conclusion arrived at is derived from personal experience, or from simple

calculation. The data on which the calculations are based are first enumerated, and they are then applied to the following cases—the price guiding either the daywork or piecework payments :—Ploughing, harrowing, rolling, grubbing, horse and hand hoeing, sowing, reaping, mowing, harvesting, threshing, digging, draining, &c. And the calculated expense of the several operations is then employed in determining the labour-cost of the several crops—seed crops, root crops, forage crops, special crops.

24. Data on which the Cost of Agricultural Labour depends.—1. *Hand power.* The wages of an ordinary labouring man are assumed to be 2s. a day, except during about five weeks of harvest time, when they are put at 3s. 6d. to 4s. a day of ten hours. Those of a woman working in a field are 10d. a day of ten hours, except during harvest time, when they are 1s. 3d. to 1s. 6d. Those of a boy vary from 2s. a week, the wages of a "scare-crow," up to perhaps 1s. 6d. or more per day, as he approaches manhood.—2. *Horse power.* The cost of a horse, as worked on the average, *i.e.*, under the varying circumstances of farm labour, with one man to a pair, or occasionally one to each animal, amounts to nearly 5d. per working hour throughout the year. The cost by horse power of 1 cwt. drawn (=lifted) 2½ miles in one hour is about 6d. The annual cost of food—of extras, such as farriery, maintenance, saddlery, &c.—of guidance and management—and of maintenance of implements is £23, £5, £15, and £3 respectively, or £46 a horse; and this, if the working time be 2,400 hours, amounts in all to nearly 5d. an hour as has been said; if the time of labour be, as is estimated by some, 2,700 hours per annum, whether 300 days of nine hours each, or 270 days of ten hours each, then the cost is less than 4¼d. per hour. If the mean of these figures be taken as a guide, then a pair of horses at 9d. an hour, and nine hours a day, will cost 6s. 9d. a day. And to this the figures of already published estimates sufficiently agree: thus Professor Low calculates the daily cost of a pair horses (for nine hours) at 4s. 8d., which, with ordinary wages for the ploughman, is nearly the same as the above; when the day is ten hours, the cost is, of course, so much more, or 7s. 6d. a day.—3. *Steam power.* Its cost varies considerably according to the size and quality of the engine. I do not quote the returns of what are called "racing" trials of the moveable and fixed engines of the different makers at the annual meeting of the Agricultural Societies, because, although an enormous power may be obtained from the consumption of a

very small quantity of coals under the particular circumstances of any given hour for which special preparation has been made, such results are never realised in ordinary practice; and it may, therefore, be put down as the ordinary experience, that 1 cwt. of coals per horse power is consumed during a day of ten hours; and that, in the case of eight to ten horse power moveable engines, the cost of coals, labour, water, oil, getting up steam, repairs, and moving from place to place, amounts to from less than 3d. per horse power in the larger engines, to 4d., or even more, in the case of the smaller engines; varying also, of course, between even wider extremes than these, according to the price of coals in the different localities compared.

25. Cost of Farm Operations.—1. *Ploughing.* Let us suppose it capable of being done by a man and pair of horses, involving a draught (=a lift) of 3 cwt. for 10 miles per acre (four times the distance along which, according to the datum already determined, 1 cwt. can be drawn for 6d). It will cost 3 × 4 × 6d.=6s. per acre. 1¼ acres should be done in 10 hours; and this at 4½d. per horse per hour (the other datum) brings the cost=10 × 2 × 4½d.=7s. 6d. per 1¼ acres, or 6s. an acre as before. If deeper, it may involve a draught of even 5 cwt., and then a wider furrow slice being taken, 8 miles are walked per acre; 5 cwt. drawn 8 miles are equivalent to 16 cwt. drawn 2½ miles, and the operation will thus cost 8s. an acre. Calculated the other way, 3 horses would probably be taken for the work, and they should do 1¼ acres a day in 10 hours, costing 3 × 10 × 4½d. or 11s. 3d., rather more than 8s. an acre. But these figures are much larger than are to be quoted against the operations if effected by steam power; for we then calculate on 3d. per horse power per hour, and on a larger quantity of work being accomplished, owing to less loss of time on the headlands.

There is comparatively little service done by estimating the cost and performance of any of the kinds of apparatus for steam ploughing or steam cultivation in actual work during a single day; but it may be now safely contended that the operations of both ploughing and grubbing land can be more cheaply done by steam power than by horses; especially where, owing to the depth of work, or the stiffness of the soil, the labour is excessive. We may in fact safely estimate that steam power will generally plough land at probably 60 per cent. of the cost of ordinary horse power cultivation, and on stiff clay soils with nearly double the efficiency. The cost of steam power as compared with that of horses may be

3d. as compared with 4½d. for the same amount of force exerted: but in the case of steam ploughing, the loss of time on headlands is so much less as to raise the difference between the two thus much in favour of the former. And as to the quality of the work accomplished by them, it is becoming more and more the experience of steam-cultivators that the grubber driven by steam power is especially the tool for the production of tilth.

The state called tilth is however not altogether, nor even chiefly, an artificial thing. You might grind clods, and even rocks, to powder, but the powdered stuff would not be mould, nor would the condition to which the material would be thus reduced be the state we call tilth. The hardened soil must be moved, of course, by artificial means, broken into fragments, and the labour of such heavy work particularly adapts it to steam power; but these fragments, large or small, must moulder down by the influence of the weather. It is a great mistake to suppose that steam power will be best applied to the work of cultivation by setting it to grind the hard ground artificially to powder. Even if this could be done, it would most likely end not in creating but in retarding tilth: the powdered soil would run together in a mass on the first rain which should thoroughly soak it. The great object of the tillage-farmer is to break his land up into dry fragments, on a well-drained subsoil, and then leave time and weather to do their work. Frost, with alternate rain and drought, on deeply-moved and well-drained land, are the real tillage implements. The soil is thus reduced from fragments and clods by the mere costless lapse of time into that condition of soft moistened mould which is best both as seed-bed and as feeding-ground for our crops.

It is the fitness of steam power for that preliminary artificial process by which the natural and final processes are enabled and facilitated, which renders it of such inestimable value to the tillage-farmer, and which will, especially on clay-land, make steam cultivation, following drainage, the inauguration of a new era of fertility and productiveness.

2. *Harrowing.*—A man and pair of horses will, with harrows of ordinary width, *i.e.*, covering about seven or eight feet, go over rather more than nine times the land turned over by the plough, although the width of the tool is not more than nine times the width of the furrow slice. Horses at harrow ought to, and generally do, travel faster than at any other farm operation; we may therefore calculate on ten times the work of the plough being

done—equal, in a good day's work, to about twelve or thirteen acres; or, if a double turn be given on the same land, equal to six or seven acres thus treated. In the one case, then, the cost of ten hours' work (7s. 6d.) is 6½d. per acre, and in the other, 1s. 1d.

3. *Rolling*, if with one horse and a light five-foot roller, costs 3s. 9d. per day of ten hours, during which about six acres may be rolled, at a cost of 7½d. per acre; if with two horses and a six-foot roller, it costs 7s. 6d. per day of ten hours, during which eight acres may be accomplished at a cost of about 1s. an acre. If pressing after the plough be adopted, one horse will press after two ploughs; and as this is done, generally, previous to wheat sowing, when nine hours is the utmost time of a day's work, it accomplishes less than two acres, costing about 1s. 9d. to 2s. an acre. The clod-crusher (Crosskill's), drawn by three horses over rough cloddy land, will not accomplish so much, according to its width, as the common roller, and will cost at least 1s. 6d. an acre.

4. *Grubbing and Cultivating* may vary from a mere scarifying of the surface to a thorough disintegration of the soil to its full depth. Being done by horses, a pair, with Finlayson's so-called harrow, may get over four acres a day five inches deep, in the case of land already ploughed, thus costing less than 2s. an acre; or four horses may be needed, and Coleman's, Clay's, or Bentall's implement, stirring between three and four feet wide at a time, may accomplish three acres a day, six or seven inches deep, at 5s. an acre. This too, however, as has been said, is an operation perfectly manageable by steam power. Smith's (of Woolston) grubber accomplishes five acres of heavy land grubbing, and seven acres of light land grubbing with ease, by means of a seven or eight-horse engine. This is in the case of unploughed land, and, of course, involving an immensely heavier draught than is required in ordinary horse tillage, where the land may be said to be almost invariably ploughed first before the use of the grubber. The cost of grubbing by steam power varies from 3s. to 4s. an acre, in the case of stiff land. This is sufficient to pay for fuel, material of all kinds, and wages. To this must be added the cost of tear and wear of machinery. At the Bury Meeting (1867) of the Royal Agricultural Society, the use of very wide cultivators for light land cultivation by steam power was very strikingly illustrated. Travelling at the rate of four miles an hour, between two engines placed at either end of the field, Fowler's thirteen-tined cultivator accomplished the cultivation of

the land to a depth of about six inches, and the piece actually worked within the hour was or rather more than five acres. It is plain that these two engines, of ten and twelve-horse power, consuming at most a ton of coals a day, and involving at most the wages of five hands and the cost of a horse and cart, cannot anyhow be made to expend more than 50s. a day in current outgoings. But this is not more than 1s. an acre of the extent of land which, on the large fields of light land in the eastern counties, they will be able to get over with their cultivating tool.

5. *Hoeing.*—The hoeing of corn by Garrett's horse hoe, with attendant lad to lead the horse, costing about 6s. a day, will cost in general considerably less than 1s. an acre. One-horse hoeing between the drills of turnips, where one interval is thus grubbed at a time, will generally be done at the rate of three acres a day, and may therefore be estimated at 1s. 6d. an acre. To hand-hoe drilled corn costs from 3s. 6d. to 5s. an acre, according to the nearness of the rows and the softness and cleanness of the land. To hoe, and at the same time single turnips sown broadcast, costs from 8s. to 10s. an acre, according as three hoeings are needed, the second and third being done some weeks after the first, when a second cleaning may be necessary, and an additional singling may be needed. To hand-hoe, *i.e.*, single the rows of drilled turnips, costs 3s. to 3s. 6d. an acre. The second hoeing in this case, which overtakes the land left by the horse-hoe, may be done for 2s. an acre. To hand-hoe potatoes, *i.e.*, hack the intervals between the rows deeply with a heavy adze-like tool, costs about 8s. an acre; to earth them up, which is done with a wide hoe, costs about 5s. or 6s. an acre. Both of these operations may be done in part by horse-drawn implements—the horse-hoe to grub the intervals, leaving the mere line of the young plants to be hoed by hand, and the double mould board plough to earth up the plants as soon as they are high enough. There is thus horse work equal to a double horse-hoeing, besides the partial hand-hoeing, in place of the hacking and moulding up all by hand, or probably 7s. or 8s. worth of labour in place of 14s. or 15s. worth.

6. *Sowing.*—This, as done by the Suffolk drill, generally requires three horses, two men, and a boy, costing 12s. 6d. to 13s. a day. A cart-load of grain will be needed for the day's work, which may cost two hours of a man and horse, or 1s., to place in position in the field, and this will make the daily cost 13s. 6d. The work done will rarely be more than 10 acres, and it will cost 1s. 4d. to 1s. 6d. an acre.—The sowing of

turnips by a double rowed turnip-drill, is done by one horse and man at the rate of 6 acres a day, and need not cost more than 9d. an acre.—The dibbling of mangold-wurzel seed by hand is done at the rate of $\frac{1}{3}$ to $\frac{1}{4}$ of an acre a day by each woman employed, and may thus cost from 2s. 6d. to 4s. an acre.—The dibbling of corn by hand costs variously, according to the implement employed. Where one hole is made at a time, and the rows are far apart, as in bean setting, and the labourer dibbling also drops the seed, it may cost 5s. or 6s. an acre. When a man using two dibbles walks backwards, making two holes at a time 9 to 10 inches apart one way, and 4 or 5 the other, followed by children dropping the seed, it costs from 5s. to 8s. an acre, according to the distance of the rows. Where Dr. Newington's seed dibble is used, covering about 2 feet at a time, the rapidity of the process is greatly increased, and its cost reduced more than one-half.—In Gloucestershire a good deal of wheat is hoed in. The man, using a flat hoe, and carrying an apron full of grain, makes a hollow track across the land, sows a handful of corn, and covers it with the earth moved in making the next track one foot further on. This costs about 8s. an acre.—Broadcast sowing may be done at the rate of 16 to 18 acres a day; and a man served by a lad with seed which has been placed out in bags by two hours' labour of a man and horse, will cost in wages and horse labour altogether about 4s. 6d. to 5s.; so that the cost varies per acre from $3\frac{1}{2}$d. to 4d. per acre.—Clover seed and grass seed sown by a seed-barrow covering 1 perch wide at once, will be accomplished easily by one man at the rate of 2 acres per hour; or, taking the cost of placing the seed in the field for him, at the cost of not more than 2d. per acre.

7. *Cutting and stooking corn* costs from 7s. an acre for a light crop up to more than double that sum for a heavy and tangled crop. The process is each succeeding harvest more and more being done by reaping machines, and the cost varies according to the crop, the machine employed, and the skill in using it.

Mr. Clare Sewell Read, M.P., of Norwich, writes thus of his experience with Burgess and Key's reaper during three years:—

"I use six horses for the machine, three off and three on; they are changed four times a day, as they start at 5 A.M. and keep on cutting till dark, stopping, of course, for breakfast, dinner, and at 4 o'clock. We don't value horses much during the early days of harvest, and I put down the six at 18s. per day. Two men or strong lads attend to the machine; one to drive it, and the other walks behind, turns the corners properly, and sees that all goes

right. These men change places as they please. A tiny boy rides the fore horse. An old man, with a scythe, rounds off the corners. I have cut, on an average, 15 acres of wheat per day, the cost for labour being :—

	£	s.	d.
"6 horses	0	18	0
2 men	0	9	0
Boy	0	0	6
Old man	0	2	6
Or 2s. per acre.	1	10	0

"Then there are the following annual charges against the machine :—

	£	s.	d.
"Repairs, wear, and tear	2	0	0
New knife	1	0	0
Oil	0	5	0
10 per cent. on £42	4	4	0
	7	9	0

or 1s. per acre on the 150 acres I cut; but I may add that my present machine has not yet cost me sixpence for repairs, and that I have only had one new knife in three years.

"Again, as to binding. I do this principally by women and girls; they have 1s. 4d. a day, working about nine hours. Two women will tie up an acre and a half in a day, so the binding by women costs only 2s. per acre; but, when I have to employ the men for that purpose, they make the cost per acre come to about 3s. 3d., for our men are hired by the harvest (having £6 for securing the crop, which seldom extends over a month), and so they earn 5s. per day. Then there is the drag-raking and the stooking (or, as we call it in Norfolk, 'shocking in'), which may be put down at 6d. per acre; so that the total cost of cutting and binding and setting-up is, per acre, 5s. 6d., when women are employed, and nearly 7s. when the men bind the corn. Before I had a reaping-machine I put out to strangers, who are never seen now, about forty acres of wheat to cut and tie, which cost me generally £8. Since then I have increased the farm to the extent of thirty acres more corn yearly, and I hire two men less, but four more women, making a total of £35 saved; from this deduct £10 for horse-labour, and £5 for wear and tear, and that leaves £20 clear profit. My harvest now costs 10s. 6d. per acre (including thatching), formerly 12s. 6d.; 2s. per acre on 350 acres is £35, which agrees with the other figures."

The following account of harvest work is by Mr. Jacob Wilson, M.R.A.C., of Manor House, Woodhouse, Morpeth :—

"I use a Burgess and Key's reaper, which cuts about 350 acres per annum, at an average of 13½ acres per day. My corn is all sheafed by long-toothed rakes, much easier for the labourers, and doing a greater quantity per day. My staff of hands consists of my usual farm-staff, viz., twenty-seven persons—nine boys or girls, nine women, and nine men, besides the man and boy with the machine. These work in gangs of three, and are arranged in systematic order as follows :—1, a boy or a girl to make bands; 2, a woman to sheaf the corn; 3, a man to bind and stock. By this means, nine swathes are taken up at once, and, as the machine generally works around the field, they also go around, but in the opposite direction. I have found that a gang (a boy, a woman, and a man) can sheaf and stock—when nicely laid—two acres per day, or on an average an acre and a half per day each—the nine gangs doing thirteen acres per day together."

I add the following account of work with Cuthbert's reaper on one of Lord River's farms, near Salisbury, given to me by Mr. Chadwin of Tollard Royal.

He says, "The reaper used by Lord Rivers upon one of his arable farms of 600 acres, is one of Cuthbert's one-horse reapers, which has proved itself a very clever and efficient implement, going through the whole of the past harvest without costing a fraction for repairs; cutting crops, which were very much laid, in the most satisfactory manner.

"The following figures will show the difference between hand-mowing and horse-reaping on this farm :—

By Hand-Labour.

Reaping, tying, and stooking, 10s. to 12s. per acre.
Mowing, tying, raking, and stooking, 7s. to 9s. per acre.

By Machine.

This reaper averaged about 10 acres per day :—

	£	s.	d.
2 men at 5s. each per day	0	10	0
1 boy	0	1	6
Oil, say	0	0	4
Food of 2 horses	0	4	0
For 10 acres	0	15	10

Or, per acre for the cutting, 1s. 7d.
For tying, stooking, and raking, 3s. 6d.
Total cost per acre by machine, 5s. 1d."

Mr. Chadwin adds, "Although this reaper is called a one-horse implement, it in reality needs two horses per day, the work being too hard for one, therefore they relieve each other at intervals; this is the usual practice, but I have found it much the best plan to feed the horses highly, and work them both at the same time throughout the day. The pace is quicker, the horses are less fatigued, and fewer stoppages occur. I do not work the same pair of horses two days in succession."

8. *Mowing* by machinery, when the circumstances are favourable, may be done at the rate of ten acres a day with a man and a pair of horses, and therefore costs less than a shilling an acre. By hand it costs, according to the table in page 117, from 2s. 6d. to 8s., and even 10s. an acre, according to the crop. Mowing meadow land is generally somewhat slower work than mowing clover, involving waste of time by the need of a more frequent sharpening of the scythe, and also in an equal crop the need of greater power; the higher price, therefore, goes to the meadow grass, and the lower price to clover.

I give one report of Burgess's mowing machine, only adding that Wood's, and other novel machines, are equally well spoken of by those who use them.

Of Burgess and Key's mower, Mr. Horswell, of Tavistock, writes as follows:—

"It answered admirably, and, though the season was very bad, I never saved hay in better condition, or with so little labour. During the eight days' uninterrupted fine weather in July (the only fine weather for the season), when men could be scarcely obtained, and for the mere labour of cutting 8s. or 10s. per acre had to be paid, I got in fifty-six acres with the aid of the mower, hay-tedder, and hay-gatherer—(the cost in manual labour, in getting it ready to be carried, did not exceed 1s. per acre), and it had no rain upon it whatever—and there were twenty-four acres besides with very little damage, all secured before the heavy rains set in. Without the aid of machinery, twenty or thirty out of the eighty acres would be the most that I could have possibly saved in good condition. Where the surface is moderately even, we can set the machine so low as to cut four or five cwt. of hay per acre more than the best men can do in the ordinary way. Since I have availed myself of the machinery that there is to aid the agriculturist, I can comfortably complete my harvesting with the labourers regularly employed on the farm."

9. *Harvesting.*—In addition to the mowing and reaping of the

crop, there is the cost of preparing it for the rick, and the carrying it there.

The labour of pitching sheaves to the cart or waggon, and building them there, and pitching from the cart or waggon to the rick, may be let to gangs of three—two men and a boy (one pitcher and one builder in the field, and one pitcher at the rick)—and need not cost more than 1s. 6d. an acre in the heaviest crop. I have let the pitching of 140 acres of wheat, barley, beans, (generally bulky crops), in this way generally for £7, or 1s. per acre, and it never costs me more than 1s. 2d. In addition to this, of course, there was the building on the rick, generally by one man and a boy, whose day's work would amount to about 8d. per acre; and one lad and three horses to carry the corn and lead the carts to and fro, costing about 8d. an acre, and the thatching 3s. a rick of every thirty sacks, or 1s. an acre; while the previous "leasing," or preparation of the straw, would be about one-third of this, or 4d. an acre.

The whole process of harvesting, as it may be thus conducted, would thus cost:—

		s.	d.
Cutting by machine, and tying and stooking		6	0
Pitching and loading		1	0
Rick building		0	8
Carrying		0	8
Thatching	1s. to	1	4
In all, per acre		9	8

As it is actually still conducted, unavoidably indeed, in many instances, owing to a bulky and laid crop the reaping alone may sometimes cost 15s. to 20s.—the carrying and building may cost 3s. or 4s. more—the thatching at 1s. per "square," *i.e.*, ten feet by ten feet, may cost rather more than 1s. an acre; and, in all, the expense of harvesting may be more than double what has been named.

It is a common contract in Gloucestershire to cut and carry hay, and build it in the rick—the farmer supplying horses—for 10s. an acre, so that the mowing costing, say 3s. 6d., the harvesting costs 6s. 6d.; but such a contract is a mere speculation—as, though 10s. may represent the average cost, yet it varies in actual experience from 5s. to 20s., and more, according to the weather.

In Middlesex, where the best hay in the world is made, the usual charge per acre for hay-making is at least double the Gloucestershire average.

Harvesting root crops, viz., the pulling, topping, and tailing, and throwing into carts, swedes, mangold-wurzel, and carrots, good crops of each, or respectively, twenty, thirty, and twelve tons per acre of each may cost 7s., 9s., and 20s. per acre, respectively.

I may give here, in illustration of this point, a detailed statement of my own experience during a single season, when twenty-nine acres of mangolds and 11 acres of swedes had to be carted off:—

The following is an account of the hands employed by the contractors in lifting 40 acres of mangolds and swedes, and the time they took to do the work, and the tons of roots placed in the store. Having a weighing machine, we weighed several cart-loads every day; the cart without its wings measured just a cubic yard; the ground was dry, and the work was either on level ground or on a gradual descent, so that the cart-load weighed twenty-two, twenty-three, and twenty-four cwt., including the earth left about the roots after they were cut off, which might be two, three, or four cwt. each cart. We, therefore, took every cart-load at a ton.

THE TIME AND NUMBER OF HANDS USED BY THE CONTRACTORS IN HARVESTING 30 ACRES MANGOLD AND 10 ACRES SWEDES.

18—.		Men pulling.	Women and Boys cutting Roots.	Filling the carts.		Acres.
				Men.	Women and Boys.	
Oct.						
17	Taking up Mangold, No. 6 field	5	10	1	9	11
18	,, ,, No. 6 ,,	5	10	1	9	
19	,, ,, No. 10 ,,	5	10	1	9	11
21	,, ,, No. 10 ,,	5	10	1	9	
22	,, ,, No. 2 ,,	5	10	1	9	5
23	,, Swedes, No. 2 ,,	5	10	1	9	14
	,, ,, No. 22 ,,					
24	,, ,, No. 24 ,,	5	10	1	9	
		40	70	7	63	

	£	s.	d.
The contract was for 29 acres of mangold, at 6s. 6d. per acre	9	8	6
Ditto ditto 11 acres of Swedes, at 5s. 6d. ,,	3	0	6
Total	£12	9	0

THE WAGES EARNED BY THE CONTRACTORS, AND PAID BY THEM TO THE HANDS THEY EMPLOYED.

	£	s.	d.
47 days of a man at 2s. a day	4	14	0
70 days of a woman at 10d. per day	2	18	4
63 days of a boy and girl at 9d. per day	2	7	3
Total	£9	19	7

Leaving £2 9s. 5d. to be divided amongst the contractors more than their daily wages of 2s.

THE EXPENSE OF HAULING THE ROOTS TO THE STORE.

No. 6.	3 days of 3 horses	= 9 days,	306 tons from	11 acres.
,, 10.	1½ day of 5 ,,	7½ ,,	242 ,, ,,	10 ,,
,, 2.	1½ day of 5 ,,	7½ ,,	190 ,, ,,	8 ,,
Nos. 22 and 24.	2 days of 6 ,,	12 ,,	192 ,, ,,	11 ,,
		36	930	40

930 loads or tons carted by 36 days of 1 horse, is 26 loads per horse per day.

THE EXPENSE OF CARTING 930 TONS OFF 40 ACRES OF MANGOLD AND SWEDES.

	£	s.	d.
36 days of a horse and cart at 3s. per day	5	8	0
7 days of a man to back and tip the carts in the stores at 2s.	0	14	0
17½ days of a boy leading carts at 8d.	0	11	8
Or at the rate of 3s. 4d. per acre	£6	13	8

THE EXPENSE OF STORING THE LOADS AND THATCHING THEM.

	£	s.	d.
3 men 7 days, 21 days of a man, at 2s. per day	2	2	0
2 boys and 2 women, 7 days each, 28 days at 10d. ...	1	3	4
Or 1s. 7½d. per acre	£3	5	4

	£	s.	d.		s.	d.	
So that the total expense of harvesting our root crop of 40 acres, was for pulling, &c.	12	9	0	or	6	3	per acre.
For carting 930 tons home	6	13	8	or	3	4	,,
For storing them	3	5	4	or	1	7½	,,
The expense of harvesting 40 acres of roots	£22	8	0	or	11	2½	,,

It may be added that when turnips are drawn in the autumn and thrown together in small conical heaps, and covered over for consumption on the ground in spring, the whole process may be let for from 5s. to 7s. 6d., according to the crop, per acre.

Harvesting carrots and parsnips costs in mere pulling and topping and tailing, from 20s. to sometimes a much larger sum an acre, in place of the 7s. or 8s. which swedes and mangold-

wurzel may cost. The labour of carrying and pitting the smaller crop is, of course, considerably less, but in all, the 11s. or 12s., which is the cost of the mangold-wurzel crop, is replaced by more than double that sum in the case of the carrot crop.

Harvesting potatoes may cost 20s. to 24s. an acre to dig, sort, pick up, and fill into carts. This, however, is the experience of Gloucestershire, where there is an especial dexterity in using the potato fork; and if men be employed to dig and gather too the cost may be much more. Where Hanson's potato digging machine is employed, the cost is considerably reduced; and two-thirds of the expense—that of digging, 15s. to 16s. an acre—is at once reduced to three or four hours' work of a man and two horses, or about 2s. 6d. an acre. The cost of an additional harrowing and picking after the harrow, or perhaps 2s. extra, must be added to this, making the cost of digging and picking up altogether not more than 10s., in place of 20s. to 24s. per acre. To cart home and pit may involve an expenditure of probably 5s. or 6s. extra.

10. *Carriage.*—A man and pair of horses in carts or waggon may carry two tons along a good road twelve miles; and that, with the return journey, will be a day's journey at a cost of 4d. or 5d. per ton per mile. Carriage on farm roads and over fields costs much more. In the instance already quoted 930 tons of mangold-wurzel were carried home for about £6 13s. 8d.; this would be from an average distance of about a quarter of a mile. 230 tons carted one mile for £6 13s. 8d. is as nearly as possible 6d. per ton per mile. But this is probably the minimum expense of carriage on a farm, where the system is perfectly organised and hurried along by contract work. Three horses and one boy going to and fro will lead one acre of a good crop of corn, per hour, weighing probably 50 cwt., a distance of a third to half of a mile; the cost will be about 1s., and 50 cwt. carried one mile cost, therefore, 2s. or 3s., or from 10d. to 1s. 3d. per ton per mile. Here, however, there is the slow gathering of the load, and the waiting at the rick to interfere with rapid work.—The carting of 120 cubic yards=60 or 70 tons of dung, is done by three horses and one man and a boy in a day, to a distance of one-third of a mile, costing about 9s. or 10s. There is thus a charge of nearly 6d. per mile against every ton of it. Here, too, there is a well-arranged system and contract work to hurry it along. In ordinary cases carriage on good roads may be charged at from 4d. to 6d per ton per mile, and on bad roads or fields from 8d to 1s., according to circumstances.

11. *Threshing.*—This, if done by hand, varies according to the grain and the bulk of straw. The work is done now almost wholly by machine; but the following prices may still be quoted as actually paid for hand labour in threshing by flail and dressing:—

	s. d.		s. d.	
Wheat	2 6	to	4 0	per qr.
Barley	1 3	to	1 6	,,
Oats	1 0	to	1 4	,,
Beans and Peas	1 0	to	2 0	,,

By steam power (moveable engine) the cost may be stated thus:—

	£ s. d.	£ s. d.
Hire of 8-horse engine and machine, with engineer and feeder		1 15 0
Cost of coals, say	0 8 0	
Cost of water (one man and horse half his time)	0 2 6	
		0 10 6
2 men and 2 lads unloading rick, and pitching to feeder, and opening sheaves	0 6 0	
1 man attending to sacks	0 2 0	
1 man and horse removing corn	0 5 0	
Labour of removing straw and chaff, and building the former, equal to 6 men ...	0 12 0	
		1 5 0
		3 10 6
Beer, 6 gallons		0 6 0
		£3 16 6

For this sum, from forty up to even sixty quarters, according to the yield, may be threshed for 1s. 6d. to 2s. a quarter.

In the case of the fixed engine, the charge for power may be put at about £1 a day for a 6-horse or 8-horse engine. In the latter case forty quarters could be easily threshed per day. The cost of labour being:—

	£ s. d.
4 men, 2 boys, 2 women, and 3 horses to deliver the opened sheaves to the feeders from the corn stack ...	1 0 0
1 feeder	0 2 6
3 women and 2 men to remove the straw and build it in the straw-house	0 6 0
2 men to attend to the removal of the grain to the granary	0 4 0
Labour	1 13 6
Beer, 6 gallons	0 6 0
Power	1 0 0
Total cost, about	£3 0 0

or about 1s. 6d. a quarter.

In another case known to me—

	£	s.	d.
2 lads brought the corn to the elevators in a railway truck	0	3	0
1 woman fed the elevator	0	0	10
2 women supplied the feeders with the open sheaves ...	0	2	0
1 feeder	0	3	0
3 women received the straw from the shaker	0	2	6
And 1 man built it in the straw-house	0	2	0
The engineer took the wheat to the granary	0	0	0
Labour	0	13	4
Power	1	0	0
Total daily cost	£1	13	4

For this sum about 140 cubic yards were threshed in a day—a quantity which yielded, say from 15 to 20 quarters, so that the cost varied from 1s. 8d. to 2s. a quarter.

Sometimes machines and engines are let out at so much a quarter; and a common charge is 1s. 4d. a quarter for wheat, and 10d. for oats or barley, or 3d. more when Hayes's Elevator is used for removing the straw. In either case two men (the feeder and the engineer) are included in the hire. The additional hands required are for supply of water and removal of grain; also for bringing the sheaves to the feeder, just as in the first case quoted, costing, therefore, 13s.; and, besides these, two men will be needed to build from the straw elevator, and this, with the beer supplied, amounts to 11s. 6d. and the coals may cost 8s., so that the additional charge is equal to 32s. 6d., or 9d. a quarter upon a probable day's work, making the cost on the whole rather more under this plan than when a fixed charge (generally 35s. a day) is made for the use of the engine.

Threshing is sometimes done by the acre—5s. an acre being about the price given for the use of machine and engine, with engineer and feeder, when the whole crop (wheat, barley, oats, and beans) is let together.

The threshing of grain by machine in cases of ordinary yield may thus be put at 2½d. to 3d. per bushel for wheat; while it is less in the case of those crops which yield more grain to a given bulk of straw. The immense superiority of machine and steam power threshing over hand labour consists not so much in the diminished cost per bushel as in the greater quickness of the process, and the ability thus at once to supply the market without materially interfering with the ordinary labour of the farm, and without exposing the labourers to a constant temptation to

dishonesty. An extra winnowing is almost always required, and it may be done as fast as two men can measure up and sack and wheel away the sacks. Two men can winnow probably 60 or 70 quarters a day, and four men, whose wages are 8s., will thus measure up at the rate of 1½d. to 2d. a quarter. If the wheat needs "reeing," in order to get the chaffy grain and weeds out of it, this will require a man's wages for every eight or ten quarters a day, according to the filth to be removed, and it may thus cost 2d. or more per quarter in addition to the winnowing.

12. *Digging.*—This costs various sums, according to its quality and depth, and the stiffness of the soil. When the soil is just turned over with a light spade, without using the foot, it may be done for 1d. per perch ($\frac{1}{160}$ of an acre)—the depth not being more than two or three inches. When it is dug over with a spade to the depth of five or six inches, the foot being used, and the land being in fair working order, it will cost at least 2d. per perch =£1 6s. 8d. per acre, and will generally cost £2 an acre. This also will be the price of forking rather deeper when the land is in a tolerably friable state.

If the grafting tool—a long straight narrow spade, taking a spit at least ten inches—is used, it will cost from 3d. to 4d. per perch.

Trenching is done by two labourers, a man and a lad. A trench two feet wide and six or seven inches deep is dug, and the topsoil removed to the other side of the field. A man working in the trench digs the subsoil over ten inches deep with the grafting tool, taking the full width of the trench and digging from one end of it to the other. A lad digs the topsoil of the next trench with the common spade, throwing the whole of the earth so moved on to the top of the dug subsoil, and so opening a new trench for the man. The lad may receive 3d. a perch and the man 5d. a perch for his work—the former may earn 1s. 6d. and the latter 2s. 6d a day—and the cost per acre is thus £5 6s. 8d.

Paring with a breast plough costs from 7s. or 8s. an acre in the case of stubble or light soil—to 15s. or 18s. in the case of tough old sward. And we may add here that burning may be contracted for at about as much, thus doubling the cost. It is understood, however, that the farmer harrows over the pared ground before the burners gather it and burn it.

Where stifle burning is adopted, the labour is so much the more tedious and the cost is greater; but the actual amount depends altogether upon the quantity of material burnt on a given extent of ground. Stifle burning consists in collecting the clods

of cultivated land in limestone districts, and with these, and afterwards with finer earth, covering heaps of weedy rubbish, to which fire has been set by a wisp of burning straw. The heaping, burning, and spreading the ashes are generally done by the piece, for 12s. to 14s. an acre. When clay land is burned in heaps, with coal or wood as fuel, it costs about 6d. per cubic yard, measured after burning, and 1d. per cubic yard for fuel, and 2d. per cubic yard for spreading the heap over the land.

Earth work generally, where the pick-axe is not used, may cost about 2d. a cubic yard to lift and place, and it will cost 1d. per cubic yard for every thirty yards run to wheel it away. This will apply to calculations for making wide open ditches not very deep; and when the grafting tool or shovel alone are used, *i.e.*, when there is no rock or subsoil needing the pickaxe. In the case of narrow and deep trenches, as for draining, the cost is more, as the workman labours under disadvantages. And a 4-foot deep drain, to take a 2-inch tube at bottom, in a clay or loamy subsoil without stones, will cost from 6d. to 8d. per perch to dig, which is 3d. to 4d. per cubic yard.

To turn dung heaps will cost from ½d. to ¾d. per cubic yard (measured after the work is completed, and it has sunk to its natural solidity), according to the strawyness of the heap. Where the hay knife is needed to cut it out in successive slices, and it has then to be thrown, as in cattle boxes, into carts or into the yard, it will cost ¾d. per cubic yard.

Well-made dung may be filled into carts for 7s. 6d. per 120 cubic yards, which is just ¾d. per yard, and good labourers will make 2s. 6d. a day at this wage.

Dung may be spread at the rate of 1s. 6d. to 2s. 6d. per acre, according to the heaviness of the dressing; and it may be spread in rows in the turnip-field by one man and three lads, as fast as three men at the carts can fill them; *i.e.*, for about the same wages, or ¾d. per cubic yard, or from 1s. 6d. to 2s. 6d. per acre, according to the dressing.

There are other works which may perhaps come under this paragraph, such as digging and grubbing up old hedgerows, and works of that class; but it is impossible to give any information of the cost of such work without seeing the character of it. It may cost from 1s. to 3s. per running perch, according to the width of the fence which needs removal. And it may be added, that the same uncertainty and variety attends the converse employment of repairing, renewing, and pleaching fences to remain,

which a man will do at the rate of three up to eight or ten rods, or perches, a day, according to its laboriousness.

13. *Live Stock Management.*—The shepherd will shift the hurdles and troughs for chaff, and peck the turnips for 300 or 350 sheep folded on turnips, having the daily supply of hay chaff cut for him, and brought to him in the field. Attendance on feeding sheep may thus be estimated as costing ½d. per sheep per week, and ½d. more in cutting chaff, &c., when they receive other feeding. And where sheep are kept in yards, and cut turnips are supplied to them in troughs, the cost will not be much more. A man and boy can clean and cut with Gardner's turnip-cutter from three to five tons of roots a day, and supply them in three meals, and keep the bedding trim; and this will suffice for 300 to 400 sheep. When sheep are folded on the land, and also fed on cut turnips in troughs, there is a double labour, and it will need a man and boy to attend on 300.—Shearing sheep varies with the size and weight of fleece, from 3s. 6d. to 4s. per score.—The labour of attendance on fattening cattle, when a mess of chaff and meal and steamed roots is given once or twice a day to beasts in stalls, and cut roots are given twice or thrice a day, at the rate of half a cwt. or so to each, and a little hay uncut is also given, may be estimated at 1d. a day to each beast; that is to say, a man and boy will look after forty beasts in boxes, if there be conveniences for feeding them, and supplying them with straw and water. In this case there is no labour of clearing out the soiled litter, for that accumulates under the cattle, and is covered daily with fresh straw.

Attendance upon dairy stock is measured by the number of milkers needed. One at least is required for every twelve to fourteen cows. A dairymaid and helper can make the cheese for a dairy of 100 cows, and the milking employs nearly all the hands on a pasture farm.

Recapitulation.—The following, then, are, in figures, the principal statements of the foregoing paragraphs:—

		s.	d.		s.	d.
Ploughing	per acre	6	0	to	8	0
,, by steam	,,	4	0		8	0
Harrowing (a double turn)	,,	1	1			
Rolling	,,	0	8		1	6
Drill-pressing	,,	1	9		2	0
Grubbing	,,	5	0		8	0
,, by steam power	,,	3	0		6	0

		s.	d.		s.	d.
Paring, by horse	... per acre	3	0	to	4	0
Horse-hoeing corn	... ,,	1	0			
,, turnips	... ,,	1	6			
Hand-hoeing corn	... ,,	3	6		5	0
,, turnips three times ...	... ,,	10	0			
,, ,, once	... ,,	3	0		3	6
,, potatoes, deeply ...	... ,,	8	0		10	0
,, ,, (earthing up)	... ,,	6	0		8	0
Sowing corn (by Suffolk drill) ...	... ,,	1	6			
,, turnips (2-rowed drill) ...	... ,,	0	9			
Dibbling mangold-wurzel	... ,,	2	6		4	0
,, beans	... ,,	5	0		8	0
Hoeing in wheat	... ,,	8	0		10	0
Sowing corn broadcast	... ,,	0	3		0	4
,, clover	... ,,	0	2			
Cutting and stooking corn by hand ...	... ,,	8	0		16	0
,, ,, by machine	... ,,	4	0		8	0
Mowing clover	... ,,	2	6		6	0
,, grass	... ,,	3	0		8	0
,, ,, by machine	... ,,	1	0		1	6
Haymaking (including mowing) ...	... ,,	10	0		25	0
Pitching corn in sheaves from field to rick	... ,,	1	0		1	6
Building corn in rick	... ,,	0	8			
Carriage from field	... ,,	0	8		1	0
Thatching	... ,,	1	0		1	4
Carriage per mile	... per ton	0	6		1	0
Harvesting swedes, mangold-wurzel ...	... per acre	10	0		14	0
Pulling and filling carrots	... ,,	20	0		25	0
,, ,, potatoes	... ,,	20	0		25	0
Threshing by hand, wheat	... per qr.	2	6		4	0
,, ,, barley	... ,,	1	3		1	6
,, ,, oats	... ,,	1	0		1	3
,, ,, beans and peas ...	... ,,	1	3		1	6
,, by steam power, wheat ...	... ,,	1	6		2	0
Winnowing	... ,,	0	1		0	1½
Digging, turning in	... per perch	0	1			
,, deeper	... ,,	0	2		0	3
Trenching (two spits)	... ,,	0	8			
Turning dung	per cubic yard	0	0½		0	0¾
Filling ,, ...	,,	0	0¾			
Paring (breast plough)	... per acre	7	0		15	0
,, (horse plough)	... ,,	3	0		6	0
,, and burning	... ,,	12	0		30	0
Digging ditch	per cubic yard	0	2			
,, drains, 4 feet deep	... per perch	0	6		0	8
Live Stock.—Sheep feeding, weekly ...	... per head	0	0½		0	0¾
Cattle ditto ...	... ,,	0	7		0	8
Sheep shearing	... per score	3	6		5	0

To this table I add, for the sake of comparison, the testimony of two or three of Mr. Howard's correspondents, and the prices

paid by them and reported by him to the London Farmers' Club on the occasion to which I have already referred.

The following is from Mr. Battams, of Carlton, one of our most successful farmers, who had recently retired from business leaving his sons in large farms. He says :—

"Although I have thrown the plough in the ditch, I will refer to my labour-book, and give you the prices paid upon my farms for piece and day work. I will commence with my first operation, grubbing up about sixty acres of woodland. This cost £8 per acre. It was then drained four feet deep, at 2s. 6d. per chain. I next dug with spade ninety acres of old grass covered with ant hills. This was done at £2 to £2 2s. per acre. It was then drained four feet deep, at 2s. and 2s. 3d. per chain. The old ploughed land was drained the same depth, and at the same price, except where the pickaxe was used. This cost 3s. 6d. to 4s. per chain. The above was extraordinary farm work. I had more than 100 men employed at one time, my sons superintending the work. It was done well; and the men earned 12s. to 15s. per week, and some even more, in the winter months. I now come to ordinary farm work, done by the piece :—Trimming hedges, 2d. per chain; singling turnips, and hoeing the side of the ridge after the horse-hoe, 5s. to 6s. per acre; topping and pitting turnips, 6s.; mangel-wurzel, singled by the day, and for pulling, topping, and placing in rows for carting, 3s.; bean dibbling, two feet apart, when the rows are marked out, 3s. 6d., if unmarked, 4s. 6d. per acre; hoeing ditto twice after the horse-hoe, 6s.; mowing clover, 2s.; mowing grass, 2s. 6d. to 3s. per acre, with three pints of beer per day; mowing, sheafing, raking, and shocking wheat, barley, and oats, 7s. to 8s.; pea hooking, 4s. 6d. to 5s. 6d.; bean hooking, 7s. 6d. per acre, with four pints of beer per day; thatching, 1s. per square of 100 feet, with beer; harvest carting, 3s. 6d. per day; ordinary day labour, 11s. per week; men attending the steam engine, 15s. per week, with beer; horsekeepers and shepherds, 12s. per week, with house and garden rent free. I think it desirable to have work done by the piece where practicable; but I find three-fourths of the ordinary work of the farm is performed by the day, and I cannot well see how it is to be avoided, with so many men attending stock, and the threshing, chaff-cutting, grinding, and a great part of the cultivation of land done by the steam-engine; but even this day labour may be done very satisfactorily, where a good feeling exists between the master and the men, the former devoting sufficient time to the superintendence

of the workmen." Mr. Battams adds, "I have not noticed the cost of paring and burning old grass land, as I think the necessity of doing it almost exceptional. I prefer double ploughing; what I have burnt cost £2 an acre."

The following, again, is from Mr. Hudson, of Castle Acre, Norfolk. He says:—

"There is not so much piece-work done on the farms in this district as in former times; but we prefer that system when the men will take the work. The drilling is done by the acre. The man who leads the horse, and the man who guides the drill, are paid each 3d. an acre, if the work is done well; they earn about 3s. a day each. Fencing is paid for by the rod of seven yards, at from 9d. to 1s. a rod. The manure is filled by the load, at 1½d. per load; manure heaps turned over at 1d. per load. Turnips are hoed out at 2s. per acre, and singled by hand at 1s. 6d., and hoed round each plant at 3s. an acre, besides being horse-hoed three or four times between the ridges. Clover is mown at from 2s. to 3s. 6d., and 4s. an acre. The harvest work is taken by the men on the farm, who cut the barley and oats, and pitch, load, and stack the whole of the crop, including wheat, at from £6 to £6 10s. per man, the wheat being cut by machines, and tied up by women, at from 2s. 6d. to 3s. an acre, according to crop. Barley is gathered and heaped at 6d. an acre. In the autumn the swedes are placed in rows of from six to eight drills together, at 2s. 6d. an acre. If topped and tailed, and loaded on carts, or heaped ready to cover up, 4s. an acre [extra?]. Stones are gathered from the clover, and put at once on carts, instead of being laid on the ground in heaps, at 1s. per load of twenty-four bushels. Hay stacks are thatched at 4d. a yard run at the eaves; corn stacks at 5d. per yard run."

Mr. C. S. Read writes:—

"Very little ploughing is done by the piece, certainly not with horses; but many farmers put out ploughing to their bullock men, the bullocks being changed four times a day, and four bullocks being allotted to a plough, the price varying from 1s. 2d. to 1s. 8d. per acre, the depth and stiffness of the land of course regulating the price. I am in favour of well-paid piece-work, and a comparatively low price for daily labour; if your day's pay is high, the men do not like to take piece-work, and having piece-work is the only way we can make the proper difference between the good and indifferent labourer."

26. Labour-Cost of Crops.—We have now to apply these

particulars to ascertain the labour-cost of different farm crops. For some of the crops named it will be necessary to add information on particulars not yet mentioned. I shall not pretend to specify all the crops known to English agriculture; the following estimates relate only to the commonly cultivated crops, and only to the labour employed on them, leaving questions of rent, manure, interest of capital, &c., to be discussed elsewhere. The crops enumerated are wheat, barley, oats, peas, beans, rye, turnips, wurzel, carrots, cabbage, vetches, rape, flax, clover, pasture land.

It is assumed that reaping and mowing are done by machine, that horse-hoes are used in place of hand-hoes where possible, and that horse, not steam, cultivation is the rule. But the alternatives of hand hoeing and hand reaping on the one hand, and of steam cultivation on the other are suggested and worked out to their results.

1. *Wheat.*—The following are estimates of the labour-cost per acre of this crop under various modes of cultivation.

(*a.*) After clover :—

	s.	d.	£	s.	d.
Ploughing			0	6	0
Two double harrowings			0	2	2
Drilling seed			0	1	6
Harrowing			0	1	1
Water furrowing, probably			0	1	0
Bird-scaring at seed time			0	1	6
Rolling			0	0	9
Horse-hoeing			0	1	0
Hand-weeding, probably			0	2	0
Bird-scaring before harvest			0	1	6
Cutting corn by machine			0	6	0
Pitching, carrying, building, and thatching			0	4	0
Threshing by steam power (5 qrs.)			0	10	0
Carriage to market (5 qrs.), probably			0	5	0
Cost per acre of labour			£2	3	6
Extra :—					
If weed patches need forking out of clover ...	2	0			
If reaping be done by hand	4	0			
If hoeing be done by hand	3	0	0	9	0
If a dressing of 15 tons of manure be carried on the clover before ploughing—					
Making dung	2	6			
Filling	1	6			
Carrying	5	0			
Spreading	2	0	0	11	0
Total labour-cost per acre			3	3	6

(*b.*) After bare fallow:—

	£	s.	d.
Cultivation of fallow—three ploughings and six double harrowings	1	7	0
Gathering and removing weeds (perhaps)	0	5	0
Seed furrow (ploughing)	0	6	0
One harrowing	0	1	1
Drilling seed, &c. as in (*a.*)	1	15	4
	3	14	5
Add, if reaping and hoeing be done by hand	0	7	0
Labour-cost per acre	£4	1	5

(*c.*) After Root crop:—

	£	s.	d.
The same items as in (*a.*)	2	3	6
Or if one grubbing be given in place of the ploughing (2s. 6d. in place of 6s.), deduct	0	3	6
	2	0	0
Add, if reaping and hoeing be done by hand	0	7	0
Labour-cost per acre	£2	7	0

2. *Barley*:—

		£	s.	d.
Ploughing after the sheep fold		0	6	0
Two double harrowings		0	2	2
Drilling seed		0	1	6
Harrowing		0	1	1
Rolling		0	0	8
Bird-scaring		0	1	6
Cutting by machine, turning, loading, building, thatching		0	9	0
Threshing (7 qrs.)		0	10	0
Carriage to market		0	5	0
		£1	16	11
Add, if cutting by hook, tying in sheaves, and stooking be adopted	1 0	0	3	0
Total labour-cost per acre of the barley crop ...		£1	19	11

3. *Oats.*

(*a.*) After Clover:—

	£	s.	d.
A good crop will involve an expenditure as nearly as possible like (both in items and in total cost) that of wheat after clover (*a.*) viz., ...	2	3	6
Or if the weed-forking, hand-reaping, and hand-hoeing be required, add	0	9	0
Labour-cost per acre	£2	12	6

(*b.*) After Root crop :—

		£	s.	d.
A good crop will involve an expenditure as nearly as possible like (both in items and in total cost) that of barley after roots		1	16	11
Or with additions		0	3	0
Total labour-cost of oats per acre		£1	19	11

4. *Peas.*

(*a.*) After Corn crop :—

	s. d.	£	s.	d.
Shallow grubbing stubble		0	2	6
Harrowing		0	1	1
Gathering and burning weeds (probably)		0	3	0
A dressing of 12 tons manure :—				
Making	2 0			
Filling	1 6			
Carrying	4 0			
Spreading	2 0			
		0	9	6
Ploughing		0	6	0
Harrowing		0	1	1
Sowing by Suffolk drill		0	1	6
Harrowing		0	1	1
Bird-scaring at seed time		0	1	3
Horse-hoeing		0	1	6
Hand-weeding		0	3	0
Bird-scaring before harvest		0	1	6
Cutting by scythe and harvesting, carrying, building, and thatching		0	8	0
Threshing (5 qrs.)		0	7	6
Carrying to market		0	5	0
Labour-cost per acre		£2	13	6

(*b.*) Grown for Green Peas :

	£	s.	d.
Cultivation by grubber and hand-weeding, as before ...	0	6	7
Manuring, and ploughing, and harrowing, as before ...	0	16	7
Ribbing, half ploughing	0	3	0
Sowing in the drills	0	1	6
Covering by hand-hoe	0	2	6
Bird-scaring	0	1	0
Horse-hoeing	0	1	6
Hand-hoeing	0	3	0
Earthing up by plough	0	3	0
	£1	18	8

The crop is sold on the ground, and followed by turnip or rape.

(*c.*) After Root crop :—

	£	s.	d.
Items and cost as in (*a.*) after the dressing of manure ...	1	17	5

5. *Beans.*

(*a.*) On Corn stubble manured :—

	£	s.	d.
The same as for peas (*a.*), excepting that the cost of harvesting will be at least 2s. more, for tying in sheaves, &c.	2	15	6

It may be sown by bean-barrow, in the wake of every second plough, but this will not affect the labour-cost.

(*b.*) After Root crop :—

The same as for peas (*c.*), excepting that the harvesting will be at least 2s. more for tying in sheaves, &c. ...			1	19	5

(*c.*) After Clover or Grass :—

	s.	d.	£	s.	d.
The same as (*b.*)			1	18	8
Except for digging weeds, add, probably ...	2	0			
Extra harrowings required	1	1			
If dibbled instead of being sown	5	6			
			0	8	7
Labour-cost of beans per acre			£2	7	0

(*d.*) After Grain crop, and ridged as in turnip culture :—

	£	s.	d.
The same as (*a*), excepting that the manure being spread in drills, there is the cost of ribbing the land, spreading the dung in drills, sowing the seed by barrow and splitting the intervals to cover it, in place of broadcasting the manure and ploughing it under, and harrowing and sowing by Suffolk drill. Also there is an opportunity of an extra horse-hoeing and moulding up ; the labour-cost will be probably 4s. greater, or ...	2	17	6

In all cases of manuring the expense of making and applying the manure will vary from 6s. to 10s., and even 15s. per acre, according to quantity, being about 9d. per ton.

6. *Rye.*

(*a.*) May be sown on a manured Corn stubble :—

	£	s.	d.
Costing, if thoroughly well cultivated, nearly the same as peas (*a.*), or	2	13	6
Deducting for diminished labour, owing to the lighter soil on which it is cultivated, probably	2	10	0

(*b.*) But in general it is grown as a forage crop :—

Costing as peas (*a.*), up till the brairding of the seed, or	1	7	0
And then, after mowing (2s. 6d.), carried to the feeding stalls, say, 8d. per mile, 3s. 6d.	0	6	0
Labour-cost per acre of rye forage	£1	13	0

7. *Turnips.*

(*a.*) After Corn crop:—

			s.	d.
Grubbing			3	6
Harrowing			2	2
Gathering and burning weeds			3	0
Deep ploughing			8	0
Harrowing			1	1
Grubbing			3	6
Harrowing			2	2
Rolling			1	0
Gathering and burning weeds			2	0
Ploughing			6	0
Harrowing			1	1
Rolling			1	0
Ribbing			2	6
Dressing with 18 to 20 tons manure:—	s.	d.		
Making	3	6		
Filling	2	6		
Carriage	3	6		
Spreading	2	0		
			11	6
Covering dung			2	6
Sowing			0	9
Two horse-hoeings			3	0
Hand-hoeing			4	0
Two horse-hoeings			3	0
Hand-hoeing			2	0
Harvesting and pitting			12	0
			£3 15	9

	£	s.	d.
(*b.*) Or in place of grubbing and autumnal cultivation, it may suffice to fork out patches of root weeds, haul on the dung and plough it under in autumn, and be satisfied with grubbing, rolling, harrowing, and sowing on the flat in spring, in which case at least 15s. worth of ploughing, grubbing, harrowing are saved, and the cost will be about	3	0	0
(*c.*) Or the roots may be consumed on the ground, and the expense of harvesting will be saved, reducing cost to ...	2	8	0
(*d.*) If the autumnal ploughing be done by steam, it will be done more efficiently, at a saving of 3s. or 4s., reducing cost to	2	5	0

8. *Mangold-Wurzel.*

Its labour-cost will be as nearly as possible identical with that of turnips, adding perhaps 2s. per acre to the expense of harvesting what will generally be a heavier crop.

	£	s.	d.
(*a.*)	3	18	0
(*b.*)	3	0	0
(*c.*) Where roots are at once consumed on the land, which is coming to be the practice to some extent ...	2	8	0
(*d.*)	2	5	0

If seed is dibbled instead of drilled, the cost will be in every case at least 2s. more than this. The cost of singling will not be altered, but the total cost will then stand thus:—(*a.*) £4, (*b.*) £3 2s., (*c.*) £2 10s., (*d.*) £2 7s.

9. *Carrots and Parsnips*:—

These crops may be named together, as costing nearly the same.

	£	s.	d.
The expense before winter, as in the case of the turnips (*a.*)	0	15	8
Only the manure should have been carted on before the autumn ploughing	0	11	6
Harrowing	0	2	2
Gathering weeds	0	2	0
Sowing	0	1	6
Horse-hoeing	0	1	6
Singling	0	5	0
Horse and hand-hoeing	0	5	0
Harvesting	1	5	0
In all	£3	9	4

10. *Cabbages*:—

The labour-cost may be the same as for turnips in ridges, up till sowing the seed, viz. (*a.*)	2	10	0
Afterwards there is the planting 10,000 plants	0	12	0
Two horse-hoeings and one hand-hoeing	0	6	0
Harvesting, probably	0	10	0
In all	£3	18	0

11. *Potatoes*:—

(*a.*) By horse-culture, labour up to setting the tubers, as in turnips (*a.*), up to covering in the dung	2	7	6
Setting tubers (carted to the field)	0	3	6
Covering	0	3	6
Harrowing down	0	1	1
Two horse-hoeings	0	3	0
Hand-hoeing	0	8	0
Earthing up	0	2	6
Digging and harvesting	1	10	0
	£4	19	1
(*b.*) By hand-culture, labour up to ribbing for receiving the dung, the same as turnips (*a.*)	1	13	6
Carrying manure and spreading	0	11	6
Digging and planting potatoes	0	14	0
Hacking	0	10	0
Earthing up	0	6	0
Digging and harvesting	1	10	0
Labour-cost of potatoes per acre	£5	5	0

12. *Vetches:—*

	£	s.	d.
Sown after a corn crop and manured, will cost in labour, including the drilling of the seed, the same as rye as a forage crop	1	7	0
And carried home to the feeding stalls, 8s. to 12s., according to crop	0	10	0
	£1	17	0

13. *Rape.*

(*a.*) Sown on a Corn stubble:—

Autumn cultivation—manuring and sowing the seed on the flat—will involve nearly the same items of labour as turnips sown on the flat, and consumed on the ground, viz. (*c.*)	2	8	0
Deduct, however, for three horse-hoeings and one hand-hoeing not needed	0	8	0
Leaving the cost, including one horse-hoeing and a partial hand-hoeing	2	0	0

(*b.*) Sown after an early crop of Rye and Vetches:—

Two grubbings and harrowings	0	8	2
Dressing of manure (12 tons)	0	9	6
Ploughing and harrowing	0	8	2
Sowing	0	1	6
Horse and hand-hoeing	0	3	6
	£1	10	10

14. *Flax.*

After Root crop:—

Ploughing	0	6	0
Harrowings	0	2	2
Weeding	0	3	0
Ploughing	0	6	0
Harrowing	0	1	1
Scarifying and harrowing	0	4	3
Rolling	0	0	9
Sowing broadcast, by machine	0	0	3
*Weeding, pulling, rippling, and steeping	1	2	0
Taking from steep, spreading, turning, and lifting ...	1	12	6
Scutching 30 stones	2	0	0
Cleaning seed	0	6	0
Labour-cost of flax	£6	4	0

* These items are stated on the authority of Mr. M'Adam, in his Prize Essay, in vol. viii. *Agricultural Society's Journal.*

If less seed be sown, and a coarser fibre with larger quantity of seed be obtained, the two last items will be somewhat larger.

15. *Clover:—*

	£	s.	d.
(*a.*) Sowing broadcast on young barley	0	0	3
Rolling and picking stones	0	2	9
Mowing	0	4	0
Making and building, 6s. to 10s., according to weather and crop	0	8	0
Carrying	0	2	6
	£0	17	6

(*b.*) When the clover is fed down, the last three items are saved, and the cost per acre is only 3*s.*

	£	s.	d.	£	s.	d.
(*c.*) When mown green and carried as forage, it may cost for mowing twice	0	8	0			
And carrying green twice	0	8	0			
Or with sowing, &c., probably				1	0	0

16. *Rye Grass:—*

	£	s.	d.
Will cost in labour the same as clover (*a.*). The labour of sowing it is somewhat greater; that of mowing it may be also somewhat greater. The cost of hay-making will probably be as much = ...	0	18	0

17. *Pasture Land:—*

	£	s.	d.
Mown every other year, and the stones gathered off it, and rolled; fence mending at intervals, &c., charge per acre per annum = ... 0 6 0 to	0	7	6

18. *Attendance on Sheep:—*

	£	s.	d.
Per head per week—less all the year round than ...	0	0	0½

19. *Attendance on Cattle:—*

	d.	d.	£	s.	d.
On an average per head, winter feeding per week	7 to	9			
Summer, barely	1				
Average throughout the year, per week ...			0	0	4

Recapitulation:—The following, then, in tabular form, are the results arrived at. The first money column states the labour-cost per acre; the second, third, and fourth state the labour-cost per bushel and per ton on various estimates of crop.

LABOUR-COST OF GRAIN CROPS.

	Per Acre.			Per Bushel.											
				30 Bushels.			40 Bushels.			50 Bushels.			60 Bushels.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Wheat, (*a.*) after clover	2	3	6	0	1	5½	0	1	1	0	0	10½	0	0	9¾
,, do. manured	3	3	6	0	2	1½	0	1	7	0	1	3½	0	1	0¾
,, (*b.*) after fallow	3	14	5	0	2	6	0	1	10	0	1	6	0	1	3
,, (*c.*) after roots	2	0	0	0	1	4	0	1	0	0	0	9½	0	0	8
Barley	1	19	11	0	1	4	0	1	0	0	0	9½	0	0	8
Oats, (*a.*) after clover	2	3	6	0	1	5½	0	1	1	0	0	10½	0	0	9
,, (*b.*) after roots	1	16	11	0	1	2½	0	0	11	0	0	8½	0	0	7¼
Peas, (*a.*) after corn	2	13	6	0	1	9½	0	1	4	0	1	1	0	0	10½
,, (*b.*) green peas	1	18	8	0	1	3½	0	0	11½	0	0	9½	0	0	7¾
,, (*c.*) after roots	1	17	5	0	1	3	0	0	11½	0	0	9	0	0	7½
Beans, (*a.*) after corn	2	15	6	0	1	10	0	1	4½	0	1	1½	0	0	11
,, (*b.*) after roots	1	19	5	0	1	4	0	1	0	0	0	9½	0	0	8
,, (*c.*) after clover	2	8	0	0	1	7	0	1	2½	0	0	11½	0	0	9½
,, (*d.*) ridged ...	2	17	6	0	1	11	0	1	5	0	1	2	0	0	11½
Rye	2	10	0	0	1	8	0	1	3	0	1	0	0	0	10

LABOUR-COST OF GREEN CROPS.

	Per Acre.			Per Ton.											
				8 Tons.			12 Tons.			20 Tons.			30 Tons.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Rye (forage)	1	13	0	0	4	1½	0	2	9	0	1	7½		...	
Turnips, (*a.*) (carried) ...	3	15	9		...		0	6	3	0	3	9	0	2	6
,, (*b.*) ,, ...	3	0	0		...		0	5	0	0	3	0	0	2	0
,, (*c.*) (fed)	2	8	0		...		0	4	0	0	2	5	0	1	7
Mangold-wurzel, (*a.*) (carried)	3	18	0		...			...		0	3	10	0	2	7
,, ,, (*b.*) ,,	3	0	0		...		0	5	0	0	3	0	0	2	0
Carrots	3	9	4		...		0	5	9	0	3	5	0	2	3
Cabbages	3	10	0		...		0	5	10	0	3	6	0	2	4
Potatoes (*a.*) (horse culture)	4	19	1	0	12	0		...			...			...	
,, (*b.*) (hand culture)	5	3	0	0	12	8*		...			...			...	
Vetches	1	15	0	0	4	9	0	3	0	0	1	9		...	
Rape (*a.*)	2	0	0	0	5	0	0	3	4	0	2	0	0	1	4
,, (*b.*)	1	10	10	0	8	0	0	2	7	0	1	7		...	
Clover, (*a.*) (hay)	0	15	6		...			...			...			...	
,, (*b.*) (green)	1	0	0	0	2	6	0	1	8	0	1	1		...	
Rye grass (hay)	0	18	0		...			...			...			...	

Before leaving this section of the book, let us just test the applicability of these figures to the case of a farm or two.

* More likely to be half the weight and double the labour-cost per ton.

(*a.*) Take that of No. 17, in table 3, p. 57, where 200 acres are cultivated on the four-field course, and where 100 acres are pasture, and where the stock kept may be supposed equal, on an average, to 240 sheep and 30 beasts all the year round. The land is cultivated on the four-field course.

Crops.		Labour-cost per Acre. £	s.	d.		Total Labour-cost. £	s.	d.
50 acres wheat or 20 at	(*a.*)	2	3	6	... ...	43	10	0
and 30 manured	(*b.*)	3	3	6	... ...	95	5	0
50 ,, turnips 30	(*a.*)	3	15	0	... ...	112	10	0
20	(*c.*)	2	8	0	... ...	48	0	0
50 ,, barley		2	0	0	... ...	100	0	0
50 ,, clover 30 (hay)	(*a.*)	0	15	6	... ...	23	5	0
,, ,, 20, cut twice	(*c.*)	1	0	0	... ...	20	0	0
* Sundry labour on carriage of materials, fencing, roads, &c., on 300 acres, viz. ...					...	50	0	0
Attendance on Stock :—								
240 sheep at ½d. weekly each					...	26	0	0
30 beasts at 4d. ditto					...	26	0	0
100 acres of pasture at 5s. an acre					...	25	0	0
						£569	10	0

This sum pays for horse labour as well as wages. Deduct the cost of the horse labour, except wages paid to team men = 184*l.* (see No. 17, p. 57), and you have for wages 410*l.*, which is equal to 38*s.* an acre on the arable land, and 6*s.* an acre on the pasture, and this is probably near what is actually paid.

(*b.*) Take the case of a Nottinghamshire light land farm, No. 1, on p. 2. The cropping, according to the accounts received, must be nearly as follows on 930 acres :—

			Labour-cost. Per annum. £	s.	d.	Total. £	s.	d.
100 acres in wheat at		(*a.*)	3	3	6	317	10	0
100 acres in oats at		(*a.*)	2	3	6	217	10	0
150 acres in barley at		...	2	0	0	300	0	0
20 in peas at		(*a.*)	2	13	6	53	10	0
210 acres in wurzel and turnips	110	(*a.*)	3	18	0	429	0	0
	100	(*c.*)	2	8	0	240	0	0
350 acres in clover	100 mown ...	..	0	15	6	77	10	0
	100 do. twice	...	1	0	0	100	0	0
	150 fed ...	...	0	5	0	37	10	0
Sundry labour, as carriage of material, mending roads, fences, &c. (900 acres)						* 120	0	0
Attendance on live stock, probably 1,200 sheep, ½d. each per week						130	0	0
Total labour-cost						£2,022	10	0

* This item may be fairly put as high, seeing that it includes a number of items hardly

This includes cost of horse labour (see No. 30, p. 57, and deducting 608*l.*, *viz.* 956*l.* except wages of team men 348*l.*, you have a total paid in wages of about 1400*l.* Now the wages actually paid on that farm are 1383*l.*, which is a sufficient confirmation of the justice of our valuation.

VI. CALENDAR OF FARM LABOUR.

In this, the last section of the book, it is proposed to enumerate the labours of the several months, and estimate the quantity in each, taking the case of a farm of 300 acres, 60 of which are in permanent pasture, mown every other year, and the remainder of the farm is arable land, cultivated on an eight years' course of cropping, thus :—1. Wheat (30 acres).—2. Winter beans (10 acres), carrots (10 acres), potatoes (10 acres).—3. Wheat (30 acres).—4. Turnips (10 acres), swedes (20 acres).—5. Barley (30 acres).—6. Clover (30 acres).—7. Wheat (30 acres).—8. Mangold-wurzel (30 acres). Of the green crops, the carrots, potatoes, mangold-wurzel, and half of the turnips and swedes, and half of the clover, are carried home to the yard, there to be consumed by cattle, sheep, and pigs. All the green crops and the winter beans are manured; and as much of the manuring as possible is done in the autumn.

The calculations at the end of the calendar will relate to the circumstances of this farm, but the summary of operations named under the several months will relate to agriculture generally.

27. Monthly Operations of the Farm.—*Jauuary.* Drainage operations; carriage of manure to heaps in fields, also of lime and marl, also of grain to market; threshing grain for sale; ploughing, probably the last of the stubbles for root crops; applying clay and marl, carrying lime, &c.; attendance on cattle and sheep; road and fence mending; top-dressing pastures.

February.—Preparing for and sowing spring wheat, beans, and peas towards the end of the month; continuance of all works of carriage, viz. manures, lime, &c.; purchase of manure and seeds, and carriage home; marketing of grain and fat stock; attendance on feeding and breeding cattle, sheep, and swine; gathering stones off the meadows which are to be mown.

capable of enumeration, such as carrying corn and coal and manure from market for consumption on the farm; also lime for application at intervals of years; also every unusual expense owing to weather; also repairs of roads and fences, &c.

March.—Finishing sowing wheat, pease, beans; preparation of land for and sowing oats, barley, carrots, grass, clover, vetches; potato cultivation and planting; preparation of land for mangold-wurzel, turnips, cabbage, flax; turning manure heaps in the field and yard, for use in the cabbage or mangold-wurzel fields; threshing, if necessary, for marketing or for straw; attendance on fatting and breeding stock of all kinds; marketing; mowing-fields to be cleaned, harrowed, rolled, and shut up.

April.—Finishing sowing oats, barley, carrots, grass, and clover seeds; also potato planting, and, if possible, mangold-wurzel sowing; sowing sainfoin, vetches, flax; cleaning out yard and carrying to field all the manure for turnip fields; horse-hoeing wheat, and possibly beans and peas; attendance on breeding and feeding stock of all kinds.

May.—Finishing sowing of mangold-wurzel; transplanting cabbage; preparation of land for turnips; horse and hand-hoeing grain crops; also carrots and parsnips and early-planted potatoes; cutting and carrying green rye and vetches. Cattle fed in houses or turned out to pasture; sheep in pastures; sheep-shearing.

June.—Sowing turnips; horse and hand-hoeing mangold-wurzel, carrots, parsnips, beans, cabbages, potatoes; preparing land still for turnips, rape, &c. Attendance on cattle and sheep in pastures; sheep-shearing; haymaking.

July.—A last horse-hoeing of carrots and parsnips; finishing sowing turnips as a main crop; sowing rape and mustard; mowing clovers and meadows; haymaking; harvesting peas and winter beans; ploughing and sowing turnips and rape, after rye and vetches; pulling flax when ripe enough; horse and hand-hoeing turnips and mangold-wurzel; carriage of tiles, road material, &c., for autumn and winter use; also of lime for use on either clover or corn stubble.

August.—Wheat, barley, oat, bean harvest; finishing haymaking; horse-hoeing turnips and mangold-wurzel; ploughing and scarifying stubbles; finishing sowing turnip and rape after vetches or corn crop.

September.—Corn harvest; autumn cultivation; ploughing clovers (after in some cases carrying manure on them) for wheat; sowing trifolium on corn stubbles.

October.—Finishing corn harvest; preparation for and sowing wheat, rye, winter beans, winter vetches; harvesting potatoes, swedes, and mangold-wurzel; autumn cultivation of stubbles; carrying and application of lime, also of manure, on fields for root crops. Folding sheep on turnips.

November.—Wheat sowing; finishing harvesting swedes, mangold-wurzel, carrots, potatoes; continuing to carry manure on to stubbles and ploughing them in; also ploughing clover and grass lands for oats; threshing grain for market and for straw. Attendance on cattle in stalls, and sheep on turnips in the field. Road mending, draining, chalking, marling.

December.—Wheat sowing in favourable weather. Continuing ploughing stubbles, and finishing ploughing lea for oats; threshing and marketing; carriage of manure to field. Attendance on fattening stock in stalls, yards, and fields.

28. Estimated Labour of the Farm.—The following is the estimate referred to in the opening paragraph of the previous section. First, as regards horse labour:—

NO. I.—WHEAT AFTER MANGOLD-WURZEL, 30 ACRES.

The kind of work required for a crop of Wheat.	The months when the work should be done.	Days' work of a man and two horses.
To gathering and carting off mangold leaves	November.	5
,, ploughing the land after the roots are off	Nov. and Dec.	30
,, harrowing the land a double time ...	December.	6
,, drilling the seed	,,	3
,, harrowing the land a double time ...	,,	6
,, carriage of crop	August.	6

This crop of wheat requires six days of two horses in August, twenty days of two horses in November, and 35 days' work of two horses in December.

NO. 2.—30 ACRES; 10 ACRES TO BE IN WINTER BEANS.

The kind of labour required for Beans.	The months to do the work.	Days' work of a man and two horses.
To cultivating the land twice across each other	August.	9
,, two double turns of the harrow	,,	4
,, carting 200 loads of manure	September.	4
,, ploughing the land	,,	10
,, two double turns of the harrow	,,	4
,, drilling the beans	,,	2
,, horse-hoeing twice	April.	2
,, earthing up	May.	2
,, carrying crop	July.	3

These ten acres of No. 2 require thirteen days' work of two horses in August, twenty days in September, two days in April, two days in May, and three days in July.

NO. 2.—10 ACRES IN CARROTS.

The kind of work required for Carrots.	Time when the work should be done.	Days' work of a man and two horses.
To carting 250 loads of manure	October.	4
,, ploughing in the manure 8 inches deep ...	,,	10
,, cultivating twice across	March.	4
,, harrowing two double times	,,	4
,, rolling and drilling	April.	3
,, horse-hoeing	June and July.	3
,, carriage of crop	October.	3

This crop of ten acres requires eighteen days' work of a pair of horses in October, and eight days in March, three days in April, one day in June, and two days in July.

NO. 2.—10 ACRES IN POTATOES.

The kind of work required for Potatoes.	Time when the work should be done.	Days' work of a man and two horses.
To carting 250 loads of manure	September.	4
,, ploughing in the manure deep	,,	10
,, ploughing the land the second time ...	February.	10
,, harrowing a double time	April.	2
,, cultivating twice across	,,	5
,, harrowing double time	,,	2
,, drilling for and covering the potatoes ...	,,	6
,, horse-hoeing twice	May.	2
,, moulding up the potatoes	June.	3
,, carting off produce	October.	2

This crop requires fifteen days' work in September, ten days in February, fifteen days in April, two days in May, three days in June, and two days in October.

In all, No. 2 requires ten days' work in February, eight days' work in March, twenty days in April, four days in May, four days in June, thirteen days in August, thirty-five days in September, and twenty days in October.

NO. 3.—30 ACRES IN WHEAT.

The kind of work required for Wheat.	The months when the work should be done.	Days' work of a man and two horses.
Clearing up land	October.	5
To ploughing the land after the roots are off	Oct., Nov., Dec.	30
,, a double turn of the harrow	December.	6
,, drilling the seed	,,	3
,, a double turn of the harrow	,,	6
,, carriage of crop	August.	6

This crop of wheat requires twenty days' work of a pair of horses in October, fourteen or fifteen days in November, eighteen or nineteen days in December, and six days in the following August.

NO. 4.—30 ACRES TURNIPS AND SWEDES.

The kind of horse labour required for Turnips.	The months when the work should be done.	Days' work of a man and two horses.
To ploughing	Nov. and Dec.	30
,, carting 450 loads of manure	Feb. and March.	9 } 39
,, ploughing in the manure	April and May.	30
,, double turn of harrow	May.	6
,, cultivating the ground with three horses ...	,,	9 } 15
,, double turn of the heavy harrow	,,	6
,, rolling and harrowing	{ May. { June.	6 6
,, carting 300 loads of short prepared dung	,,	6 } 33
,, cultivating deep to mix the dung on the surface	,,	9
,, a double turn of the harrow	,,	6
,, rolling	,,	2
,, ribbing	,,	10
,, horse-hoeing swedes	July and August.	18
,, carrying off half the crop	Oct. and Nov.	10

This is four days in February, five days in March, five days in April, forty-six days in May, thirty-nine days in June, nine days in July, nine days in August, five days in October, twenty days in November, fifteen in December; in all, 157 days.

NO. 5.—30 ACRES IN BARLEY.

The kind of horse labour required.	The time when the work must be done.	Days' work of a man and pair of horses.
To ploughing the land with a shallow furrow	Jan. and March.	30
,, a double turn of the harrow	March.	6
,, drilling the seed	April.	3
,, a double turn of the harrow	,,	6
,, carrying the crop	August and Sept.	6

This field requires fifteen days of two horses in January, twenty-one days in March, nine days in April, three days in August, and three days in September.

NO. 6.—30 ACRES IN CLOVER.

The kind of work required for the Clover crop.	The time when the work should be done.	Days' work of a man and two horses.
To be rolled	April.	2
One half to be mown and carried as hay ...	July.	3
To be mown and carried green	June, July, Aug., and September.	12

This crop requires the labour of a pair of horses two days in April, three days in June, eight days in July, two days in August, and two days in September.

NO. 7.—30 ACRES IN WHEAT.

The kind of work required for a crop of Wheat.	The months when the work should be done.	Days' work of a man and two horses.
To ploughing	September.	30
,, harrowing it three double times	Sept. and Oct.	18
,, drilling the seed	October.	3
,, harrowing the land after the seed a double time	,,	6
,, carrying the crop	August.	6

This crop requires six days' work of two horses in August,

thirty-seven days' work of two horses in September, and twenty days in October.

NO. 8.—30 ACRES IN MANGOLD-WURZEL.

The kind of work required for Mangold-Wurzel.	The time to do the work.	Days' work of a man and two horses.
To ploughing first time	Oct. 10, Nov. 10, Dec. 5, Jan. 5.	30
,, harrowing double time	February.	6
,, carting 450 loads manure	,,	9
,, ploughing in dressing	Feb. 10, Mar. 20.	30
,, cultivating	March.	9
,, harrowing twice	April.	12
,, carting 300 loads that day	,,	6
,, cultivating and harrowing	,,	15
,, ribbing land for sowing	April and May.	9
,, horse-hoeing four times	May 6, June 6, July 6.	18
,, carrying off crop	Oct. and Nov.	20

This crop thus needs fifteen days' work of a man and two horses in October, twenty-five days in November, five days in December, five days in January, twenty-five days in February, twenty-nine days in March, thirty-seven days in April, eleven days in May, six days in June, and six days in July.

The following table then gives the results of the horse labour ascertained above, and distributed through the months :—

MONTHS OF THE YEAR.

No. of Crop.	Acres.	January. Days.	February. Days.	March. Days.	April. Days.	May. Days.	June. Days.	July. Days.	August. Days.	September. Days.	October. Days.	November. Days.	December. Days.
1. Wheat	30	...	...	...	...	...	...	...	6	...	...	20	35
2. Carrots	10	...	...	8	3	...	1	2	...	...	18	...	...
Beans	10	...	...	...	2	2	...	3	13	20	...	...	...
Potatoes ...	10	...	10	...	15	2	3	...	...	15	2	...	...
3. Wheat	30	...	...	...	...	...	...	...	6	...	20	14	16
4. Turnips... ... Swedes	10 } 20 }	...	4	5	5	46	39	9	9	...	5	20	15
5. Barley	30	15	...	21	9	...	...	...	3	3	...	...	...
6. Clover	30	...	...	...	2	...	3	8	2	2	...	...	...
7. Wheat	30	...	...	...	...	...	...	...	6	37	20	...	...
8. Mangold-wurzel ...	30	5	25	29	37	11	6	6	...	...	15	25	5
Total	...	20	39	63	73	61	52	28	45	77	80	79	71

688 days of a man and pair of horses are, according to this table, all that this farm of 240 acres of arable land requires for its annual cultivation. But there are sixty acres of pasture besides, which involve considerable labour in dressing with manure during winter, and carrying hay in July; for this the distribution of the arable labour gives ample means during January and July, when the horses are not fully employed. And there is also a considerable quantity of cartage in marketing, and in carriage of manures and seeds, and food for cattle, of which no account is taken in the table. Taking, however, the monthly figures there given to be pretty nearly accurate, we find that the greatest provision of horses for the labour of the farm must be in March, April, May, September, October, November, and December. If we take October as the month of greatest labour throughout the year, we find that eighty days of a team are needed, and as only twenty-two or twenty-three days fit for field work can be expected during that month, three and a half teams must be provided, or seven horses, three men, and a lad; and these must be maintained and paid throughout the year, notwithstanding that it is only during a few months that they are all needed. It is in the power of steam cultivation to reduce the demands made by the autumn cultivation and spring ploughing on the horse power of the farm; and, by its assistance at these two periods to reduce the number of horses needed throughout the year.

The next table gives an estimate of the cost of hand labour employed upon the crops in the different months of the year: the wages for man, woman, and child being taken at an ordinary amount, and the operations whose cost has been accounted for, including filling and spreading manure, hand-hoeing and weed-gathering, reaping and mowing corn and grass, haymaking, and harvesting grain crops and green crops, threshing the former, and consuming the latter. The table gives in shillings the sum paid per acre in this way in the several months.

A detailed examination of the figures in this table will not be attempted; but the figures in one case may be explained in illustration of the whole. Take that of the wheat crop No. 1:— "During the months of winter and spring, about 5s. per acre, in all, are spent in labour on threshing; during November and December, 1s. or 1s. 6d. an acre (or say three weeks of a boy for a ten-acre field) are spent in scaring birds at seed time, and the same is needed before harvest in July; 3s. and 4s. an acre are needed in April, May, and June, for hoeing and weeding the

young crop; and 10s. or 12s. an acre are needed in August and September for cutting, carrying, stalking, and threshing the crop. A root crop might be taken, and the figures in its case similarly justified. The only point, however, there requiring explanation is the charge of 6s. or 8s. a month during the winter months on account of them, which includes all the labour of managing manure for those crops, and of attendance on the live stock fed upon them.

Crop.	Average.	Number of Shillings per Acre Monthly.												Total Cost.	
		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Per Acre.	Of Crop.
														£ s. d.	£ s. d.
1. Wheat...	30	1	1	1	2	2	1	1½	6	6	...	1½	2	1 5 0	37 10 0
2. Beans ...	10	1	1	...	2	3	3	8	2	2	3	1	1	1 7 0	13 10 0
Carrots	10	2	2	2	5	...	5	3	...	...	20	10	2	2 11 0	25 10 0
Potatoes	10	...	...	...	10	4	8	...	...	8	30	...	...	3 0 0	30 0 0
3. Wheat...	30	1	1	1	2	2	...	1½	6	6	...	3	1	1 4 6	36 15 0
4. Turnips Swedes	10 20	8	8	7	2	4	4	6	1	...	2	8	8	2 18 0	87 0 0
5. Barley...	30	1	1	3	2	...	...	1½	6	6	...	...	1	1 1 6	32 5 0
6. Clover...	30	...	...	1	1	...	2	4	4	2	2	...	...	0 16 0	24 0 0
7. Wheat...	30	1	1	1	2	2	1	1½	6	6	...	2½	1	1 5 0	37 10 0
8. Mangold-wurzel	30	8	8	8	8	8	4	2	...	...	7	7	6	3 6 0	99 0 0
Total ...	240	630	630	680	740	610	520	650	890	880	860	770	600		423 0 0

From this table it would seem that the constant staff upon the farm, besides the team men, should be equal in point of wages to about £30 a month, and that extra labour, worth something like £15 or £20 a month, will be needed during the season of corn and root harvest. These wages will not, however, represent so many additional hands, because the extra work will be let to the constant hands of the farm as far as possible, and they will earn their extra wages by extra labour during extra hours.

The total wages = £423, must be increased by the labour on sixty acres of pasture land, costing about £15, and by the wages of the team men, or £117 (see No. 6, p. 57); perhaps also by something for shepherd and cowman, for although a charge has been made per acre on the roots for winter preparation and consumption, yet this expense will hardly have been covered. Let

us then put the whole wages of the farm at £540, or £560, and this will amount to 50s. an acre on the arable land, or somewhat less than this if 5s. an acre be first deducted for the permanent pasture of the farm.

The horse labour table, again, will correspond nearly in its results with farm No. 6, on page 57.

Let me add here, that if on comparing the figures in these tables with those given under the several crops in Section V., discrepancies be found to exist—as may very probably be the case, for they have not been founded on one another—an explanation may to some extent be found in the fact, that the cost of shepherding and cattle feeding is here almost or entirely included in the acreable charges on the several crops.

In conclusion, I give, as bearing on the subject, an extract from a paper read ten years ago before the London Farmers' Club, by the late Robert Baker, of Writtle, in which the cost of horse power and of wages on arable land, is stated as actually experienced by the writer.

The cultivation of the farm from 1835 to 1850 included the the following particulars :—

—	Crops.	Cultivation.					Manure.			
		Ploughing.	Scarifying.	Harrows.	Drillings.	Rollings.	Manure.	Clay and Chalk.	Guano.	Soot.
							Tons.	Tons.		Bush.
1839	Wheat	2	1	4	1	1	...	...	...	...
1840	Rye, and Tares, and Swedes drawn	5	3	8	2	3	16	40	...	...
1841	Barley	1	1	4	1	2	...	...	...	...
1842	Early Peas, Turnips, fed and drawn	4	2	4	1	1	20	Earth & Lime.	...	40
1843	White Oats	2	...	4	1	2	...	20	...	...
1844	Wheat	1	...	4	1	1	10	...	...	...
1845	Rye, and Rye and Tares, mown green, Swedish Turnips ...	5	1	6	2	3	16	...	2	30
1846	Barley	2	2	4	1	2	...	...	2	...
1847	Red Clover, twice mown ...	...	...	...	...	...	...	...	...	...
1848	Wheat	1	2	4	1	1	12	...	...	...
1849	Barley	3	1	5	1	2	6	...	...	...
1850	Green crop	3	...	...	...	...	...	...	...	... ...
		29	13	47	12	18	80	60	4	70

The following was the manual labour and general expenditure per acre :—

MANUAL LABOUR AND GENERAL EXPENDITURE PER ACRE.

	£	s.	d.
Harvesting Wheat and Barley, 15s., six times	£4	10	0
,, oats once	0	14	0
Cutting Clover, Rye, and Tares, and carting, 10s. ...	1	10	0
Pulling and carting Turnips, three times, 24s.	3	12	0
Threshing and carting 12 qrs. Wheat, 4s. 3d.	2	11	0
,, 18 qrs. Barley, 3s.	2	14	0
,, 7 qrs. Oats, 2s. 3d.	0	15	9
Tying and marketing straw	2	10	0
10)	18	16	9
Wages per acre per annum	£1	17	8

It is plain, however, that there is an omission here of all charges connected with the consumption of the crop and management of live stock, which would raise the cost to something more nearly £2 an acre. To this must be added the wages of team men, probably nearly 10s. an acre, as in the case already examined; so that Mr. Baker's figures are found to agree closely with our own. The wages of team men are included in the cost of horse labour specified in the next table.

CULTIVATION BY HORSES.

	£	s.	d.
2½ Ploughings, 8s. averaging annually	£1	0	0
1¼ Scarifyings, 3s.	0	3	9
4¾ Harrowings, 9d....	0	3	6
1¼ Drilling, 3s.	0	1	9
1¾ Rolling, 1s. 1d.	0	1	6
Striking furrows; water-furrowing	0	1	0
Hoeing	0	2	0
Sowing soot and guano and carting manure	0	3	3
Average annual cost of horse labour per acre ...	£1	18	6

These figures, coming from so great an authority as Mr. Baker, are a sufficient corroboration of the results to which the reader has been already led.

CASSELL, PETTER, AND GALPIN, BELLE SAUVAGE WORKS, LONDON, E.C.

THE STOCK-FEEDER'S MANUAL.

THE

CHEMISTRY OF FOOD

IN RELATION TO THE

BREEDING AND FEEDING

OF

LIVE STOCK.

BY

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THE FOLLOWING PAGES ARE

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TO

THE RIGHT HONORABLE

THE LORD TALBOT DE MALAHIDE, F.R.S.,

President of the Royal Irish Academy,
&c. &c. &c.,

ONE OF THE MOST ENLIGHTENED AND LIBERAL PROMOTERS

OF AGRICULTURAL IMPROVEMENTS.

THE AUTHOR IS UNDER MANY OBLIGATIONS TO HIS LORDSHIP, FOR WHICH HE CAN MAKE NO RETURN SAVE THIS PUBLIC ACKNOWLEDGMENT OF HIS INDEBTEDNESS.

PREFACE.

Some papers on the Chemistry of Food, read before the Royal Agricultural Society of Ireland and the Athy Farmers' Club, and a few articles on the Management of Live Stock, published in the *Weekly Agricultural Review*, constitute the basis of this Work. It describes the nature of the food used by the domesticated animals, explains the composition of the animal tissues, and treats generally upon the important subject of nutrition. The most recent analyses of all the kinds of food usually consumed by the animals of the farm are fully stated; and the nutritive values of those substances are in most instances given. Some information is afforded relative to the breeds and breeding of live stock; and a division of the Work is wholly devoted to the consideration of the economic production of "meat, milk, and butter."

Within the last twenty years the processes of chemical analysis have been so much improved, that the composition of organic bodies is now determined with great accuracy. The analyses of foods made from twenty to fifty years ago, possess now but little value. In this Work the analyses of

vegetables quoted are chiefly those recently performed by the distinguished Scotch chemist, Dr. Thomas Anderson, and by Dr. Voelcker. The Author believes that in no other Work of moderate size are there so many analyses of food substances given, and ventures to hope that the success of this Work may fully justify the belief that a "handy" book containing such information as that above mentioned, is much required by stock feeders.

102, *Lower Baggot Street*, *Dublin*,

APRIL, 1868.

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THE

CHEMISTRY OF FOOD.

INTRODUCTION.

WHEN Virgil composed his immortal "Bucolics," and Varro indited his profound Essays on Agriculture, the inhabitants of the British Islands were almost completely ignorant of the art of cultivating the soil. The rude spoils torn from the carcasses of savage animals protected the bodies of their hardly less savage victors; and the produce of the chase served almost exclusively to nourish the hardy frames of the ancient Celtic hunters. In early ages wild beasts abounded in the numerous and extensive forests of Britain and Ireland; but men were few, for the conditions under which the maintenance of a dense population is possible did not then exist. As civilisation progressed, men rapidly multiplied, and the demand for food increased. The pursuit of game became merely the pastime of the rich; and tame sheep and oxen furnished meat to the lowly as well as to the great. Nor were the fruits of the earth neglected; for during the latter days of the dominion of the Romans, England raised large quantities of corn. Gradually the food of the people, which at first was almost purely animal, became chiefly vegetable. The shepherds, who had supplanted the hunters, became less numerous than the tillers of land; and the era of tillage husbandry began.

At present the great mass of the rural population of these countries subsist almost exclusively upon vegetable aliment—a

diet which poverty, and not inclination, prescribes for them. Were the flesh of animals the staple food of the British peasantry, their numbers would not be nearly so large as they now are, for a given area of land is capable of sustaining a far larger number of vegetarians than of meat eaters. The Chinese are by no means averse to animal food, but they are so numerous, that they are in general obliged to content themselves on a purely vegetable diet.

In the manufacturing districts of Great Britain, there are several millions of people whose condition in relation to food is somewhat different from that of the small farmer and agricultural laborer. The artizans employed in our great industries are comparatively well paid for their toil; and the results of their labor place within their reach a fair share of animal food. This section of the population is rapidly increasing, and consequently is daily augmenting the demand for meat. The rural population is certainly not increasing; rather the reverse. Less manual labor is now expended in the operations of agriculture, and even horses are retiring before the advance of the steam plough. The only great purely vegetable-feeding class is diminishing, and the upper, the middle, and the artizan classes—the beef and mutton eating sections of society—are rapidly increasing. It is clear, then, that we are threatened with a revival of the pastoral age, and that in one way, at least, we are returning to the condition of our ancestors, whose staple food consisted of beef, mutton, and pork.

And here two questions arise. How long shall we be able to supply the increasing demand for meat? how long shall we be able to compete with the foreign feeders? These are momentous queries for the British farmer, and I trust they may be solved in a satisfactory manner. At any time during the present century the foreign or colonial grower of wheat could have undersold the British producer of that article, were the latter not protected by a tariff; but cattle could not, as a general rule, be imported into Great Britain at a cheaper rate than they could be produced at home. Were there no

corn imported, it is certain that the price of bread would be greater than it is now, even if the grain harvests had been better than they have been for some years past. A bad cereal harvest in England raises the price of flour, but only to a small and strictly limited extent, because, practically, there is no limit to the amount of bread-stuffs procurable from abroad. When, on the contrary, the turnip crop fails, or that excessive drought greatly curtails the yield of grass, the price of meat and butter increases greatly, and is but slightly modified by the importation of foreign stock.

Hitherto the difficulty of transit has been so great that we have only derived supplies of live stock from countries situated at a short distance, such as Holstein and Holland. Vast herds of cattle are fed with but little expense in America, and myriads of sheep are maintained cheaply in Australia; but the immense distances which intervene between our country and those remote and sparsely populated regions have, hitherto, prevented the superabundant supply of animal food produced therein from being available to the teeming population of the British Isles. Should, however, any cheap mode of conveying live stock, or even their flesh, from those and similarly circumstanced countries be devised, it might render the production of meat in Britain a far less profitable occupation than it is now. That we are increasing the area from whence we draw our supplies of live stock is evident from the fact, that within the last two years enormous numbers of horned stock have been imported from Spain. In that extensive country there are noble breeds of the ox; and it would appear that very large numbers of animals could be annually exported, without depriving the inhabitants of a due supply of bovine meat. As Spain is not very distant, it is likely that this traffic will be increased, and that in a short time we shall be as well supplied with Spanish beef as we are now provided with French flour. Meat is at present dear, and is likely to continue so for some time; but still it is evident that, sooner or later, the British feeders will come into keen competition

with the foreign producer of meat, and that the price of their commodity will consequently fall. The mere probability of such a state of things, were there no other reason, should induce the feeder to devote increased attention to the improvement of his stock, and to discover more economical methods of feeding them. There is still much to be learned relative to the precise nutritive values of the various feeding stuffs. The proper modes of cooking, or otherwise preparing, food, are still to be satisfactorily determined; and there are many very important questions in relation to the breeding of stock yet unanswered.

It is but fair to admit that the farmer is earnestly endeavouring to improve his art, and that he is willing, nay anxious, to obtain the co-operation of scientific men, in order to increase his knowledge of the theory as well as the practice of his ancient calling. Indeed, he not only admits the utility of science in agriculture, but often places an undue degree of value upon the theories of the chemist, of the botanist, and of the geologist. This is encouraging to the men of science; but, on the other hand, they must admit that by far the greater portion of the sum of human knowledge has been derived from the experience and observation of men utterly unacquainted with science, in the ordinary signification of that term. This portion of our knowledge is also, in its practical application, the most valuable. In the most important branch of industry—agriculture—the labors of the purely scientific man have as yet borne but scant fruit; whilst the unaided efforts of the husbandman have reclaimed from sterility extensive tracts, and caused them to "blossom as the rose." That practical men should have done so much, and scientific men so little, for agriculture, may easily be explained. Countless millions of men, during many thousands of years, have incessantly been occupied in improving the processes of mechanical agriculture, which, as an *art*, has consequently been brought to a high degree of perfection: but scientific agriculture is a creation of almost our own time, and the number of its cultivators is, and

always has been, very small; all its theories cannot, therefore, justly claim that degree of confidence which, as a rule, is only reposed in the opinions founded on the experience of practical workers in the field and in the feeding-house. Still, the farmer has derived a great amount of useful information from the chemist and physiologist; and they alone can explain to him the causes of the various phenomena which the different branches of his art present. There was a time when it was the fashion of the man of science to look down with contempt, from the lofty pedestal on which he placed himself, upon the lessons of practical experience read to him by the cultivator of the soil; whilst at the same time the farmer treated as foolish visionaries those who applied the teachings of science to the improvement of their art. But this time has happily passed away. The scientific man no longer despises the knowledge of the mere farmers, but turns to good account the information derivable from their experience; whilst the farmer, on the other side, has ceased to speak in contemptuous terms of mere "book learning." It is to this happy combination of the theorist with the practical man that the recent remarkable advance in agriculture is chiefly due; and to it we may confidently look for improvement in the economic production of meat and butter, and for the enlargement of our knowledge of the relative value of food substances.

STATEMENT OF THE NUMBER OF LIVE STOCK IN GREAT BRITAIN AND IRELAND.

	Enumerated, 1866.			Estimated, 1865.		
	Cattle.	Sheep.	Pigs.	Cattle.	Sheep.	Pigs.
England	3,307,034	15,124,541	2,066,299	3,422,165	18,691,088	2,363,724
Wales ..	541,401	1,668,663	191,604	—	—	—
Islands..	17,700	57,685	22,887	—	—	—
Scotland	937,411	5,255,077	219,716	974,437	5,683,168	146,354
Ireland .	3,493,414	3,688,742	1,299,893	3,493,414	3,688,742	1,299,893
Total	8,316,960	25,794,708	3,800,399	7,890,016	28,062,998	3,809,971

STATEMENT OF THE POPULATION AND NUMBER OF LIVE STOCK IN THE UNITED KINGDOM AND VARIOUS FOREIGN COUNTRIES, ACCORDING TO THE LATEST RETURNS.

Countries.	Date of Returns of Live Stock.	Population according to Latest Returns.	Cattle.			Sheep.	Pigs.
			Cows.	Other Cattle.	Total.		
United Kingdom	1865–66	29,070,932	3,286,308	5,030,652	8,316,960	25,795,708	3,802,399
Russia	1859–63	74,139,394	...	...	25,444,000	45,130,800	10,097,000
Denmark Proper	1861	1,662,734	756,834	361,940	1,118,774	1,751,950	300,928
Sleswig	1861	421,486	217,751	172,250	390,001	362,219	87,867
Holstein	1861	561,831	198,310	92,062	290,372	165,344	82,398
Sweden	1860	3,859,728	1,112,944	803,714	1,916,658	1,644,156	457,981
Prussia	1862	18,491,220	3,382,703	2,251,797	5,634,500	17,428,017	2,709,709
Hanover	1861	1,880,070	...	...	949,179	2,211,927	554,056
Saxony	1861	2,225,240	411,563	226,897	638,460	371,986	270,462
Wurtemburg	1861	1,720,708	466,758	490,414	957,172	683,842	216,965
Grand Duchy of Baden ...	1861	1,429,199	348,418	273,068	621,486	177,322	307,198
,, ,, Hesse ...	1863	853,315	187,442	129,211	316,653	231,787	195,596
,, ,, Nassau ...	1864	468,311	116,421	84,224	200,645	152,584	65,979
,, ,, Mecklenb. Schwerin	1857	539,258	197,622	69,215	266,837	1,198,450	157,522
,, ,, Oldenburg	1852	279,637	...	...	219,843	295,322	87,336
Holland	1864	3,618,459	943,214	390,673	1,333,887	930,136	294,636
Belgium	1856	4,529,461	...	...	1,257,649	583,485	458,418
France	1862	37,386,313	5,781,465	8,415,895	14,197,360	33,281,592	5,246,403
Spain...	1865	15,658,531	...	...	2,904,598	22,054,967	4,264,817
Austria	1863	36,267,648	6,353,086	7,904,030	14,257,116	16,964,236	8,151,608
Bavaria	1863	4,807,440	1,530,626	1,655,356	3,185,882	2,058,638	926,522
United States	1860	31,445,080	8,728,862	8,182,813	16,911,475	23,317,756	32,555,267

NUMBERS OF THE LIVE STOCK IMPORTED INTO GREAT BRITAIN DURING THE ELEVEN MONTHS ENDED 31ST NOVEMBER, 1867.

Bullocks, bulls, and cows	150,518
Calves	20,720
Sheep and lambs	504,514
Pigs	45,566
	721,318

AMOUNT OF ANIMAL FOOD IMPORTED DURING SAME PERIOD.

Bacon and hams	cwts.	452,132
Salt beef	,,	163,638
Salt pork	,,	123,257
Butter	,,	1,000,095
Lard	,,	213,599
Cheese	,,	798,267
Eggs		373,042,000

I am indebted to Professor Ferguson, Chief of the Veterinary Department of the Irish Privy Council Office, for the following statement :—

RETURN OF HORNED CATTLE EXPORTED FROM THE SEVERAL IRISH PORTS AT WHICH VETERINARY INSPECTORS HAVE BEEN APPOINTED, AND CERTIFIED AS FREE FROM DISEASE, FROM THE 18TH OF NOVEMBER, 1866, TO THE 16TH OF NOVEMBER, 1867 (52 WEEKS).

Fat Stock	187,483
Store Stock	317,331
Breeding and Dairy Stock	36,599
Total	541,413

PART I.

ON THE GROWTH AND COMPOSITION OF ANIMALS.

SECTION I.

ANIMAL AND VEGETABLE LIFE.

Functions of Plants.—It is the primary function of plants to convert the inorganic matter of the soil and air into organised structures of a highly complex nature. The food of plants is purely mineral, and consists chiefly of water, carbonic acid, and ammonia. Water is composed of the elements oxygen and hydrogen; carbonic acid is a compound of oxygen and carbon; and ammonia is formed of hydrogen and nitrogen. These four substances are termed the *organic elements*, because they form by far the larger portion—sometimes the whole—of organic bodies. The combustible portion of plants and animals is composed of the organic elements; the incombustible part is made up of potassium, sodium, and the various other elements enumerated in another page. The organic elements are furnished chiefly by the atmosphere, and the incombustible matters are supplied by the soil.

Water in the state of vapor forms, according to the temperature and other conditions of the atmosphere, from a half per cent. to four and a half per cent. of the weight of that fluid—about 1·25 per cent. being the average; carbonic acid exists in it to the extent of 1-2000th; and ammonia forms a minute portion of it—according to Dr. Angus Smith, one grain weight in 412·42 cubic feet of air (of a town), or 0·000453 per cent. It is remarkable that the most abundant

constituents of atmospheric air—oxygen and nitrogen—are not assimilable by plants, although these elements enter largely into the composition of vegetable substances. In the soil, also, the part which ministers to the wants of vegetables is relatively quite insignificant in amount.

Plants are unendowed with organs of locomotion, their food must therefore be within easy reach. Every breeze wafts gaseous nutriment to their expanded leaves, and their rootlets ramify throughout the soil in search of appropriate mineral aliment. But no matter how abundant, or however easy of reach may be the food of plants, the vegetable organism is incapable of partaking of it unless under the influence of light. Exposed to this potent stimulus, the plant collects the gaseous carbonic acid and the vaporous water, solidifies them, decomposes them, and combines their elements into new and organised forms. In effecting these changes—in conferring vitality upon the atoms of lifeless matter—the plant acts merely as the *mechanism*, the light is the *force.* As the work performed by the steam-engine is proportionate to the amount of force developed by the combustion of the fuel beneath its boiler, so is the rapidity of the elaboration of organic substances by plants proportionate to the amount of sunlight to which they are exposed. It is an axiom that matter is indestructible; we may alter its form as often as we please, but we cannot destroy a particle of it. It is the same with *force:* we may convert one kind of it into another —heat into light, or magnetism into electricity—but our power ends there; we can only cause force, or *motion*, to pass from one of its conditions to another, but its *quantity* can never be diminished by the power of man.

The principle of the Conservation of the Forces gives us a clear explanation of the fact that animals can obtain their food only through the medium of the vegetable kingdom. Plants are stationary mechanisms; they have no need to develop motive power, as animals have, in moving themselves from place to place. Their temperature is, we may say, the same

as that of the medium in which they exist. Such beings as plants do not, therefore, require the expenditure of force to maintain their vitality; on the contrary, their mechanisms are, for a beneficent purpose, constructed for the *accumulation* of force. The growing plant absorbs, together with carbonic acid, water, and ammonia, a proportionate amount of light, heat, and the various other subtile forces which have their abiding place in the sunbeam—

> "That golden chain,
> Whose strong embrace holds heaven and earth and main."

Co-incidentally with the conversion of the mineral constituents of the food of plants into organised structures—albumen, fibre, and such like substances—the light, and the heat, and the various other forces likewise suffer a change. Although the precise nature of the new force into which they are converted is still a mystery—one, too, which may never be revealed to us—still we know sufficient of it to satisfy us that it can only exist in connection with organic or organised structures. It is owing to its presence that the elements of these structures (the natural state of which is mineral) are bound together in what may be aptly designated a constrained state; or, as Liebig aptly expresses it, like the matter in a bent spring. So long as the organic structure retains its form, it will be a reservoir of latent force—which will manifest itself in some form during the recoil of the atoms of the matter forming the structure to their original mineral, or statical condition: so the bent spring, when the pressure is removed, returns to its original straight form.

Animal Life.—The chief manifestation of the life of a plant is the accumulation of force; very different are the functions of animal life. It is only by the continuous *expenditure* of force that the vitality of animals is preserved; the heat of a man's body, his power of locomotion, the performance of his daily toil, even his very faculty of thought, are all dependent upon, and to a great extent proportionate to, the amount of organised matter disorganised in his body. It is by the con-

version of this organised matter into its original mineral state of water, carbonic acid, and ammonia, that the force originally expended in arranging, through the agency of plants, its atoms, is again restored, chiefly in the form of heat and animal motive power.

Animals, as a class, are completely dependent upon vegetables for their existence. There is every reason to believe that the most lowly organised beings in the scale of animal life, even those of so simple a structure as to have been long regarded as vegetables or as plant-animals, are incapable of organising mineral matter. The so-called vegetative life of animals—for I believe the term to be exceedingly inexact—is applied to their growth, that is, to the increase in their weight. This increase takes place by their power of reorganising, or of assimilating to the nature of their own organisms, certain of the substances elaborated by plants, and destined to become food for animals.

SECTION II.

COMPOSITION OF ORGANIC SUBSTANCES.

Elements of Organic Bodies.—The number of distinct kinds of substances—each distinguishable from all the others by the peculiarity of its properties, taken as a whole—is exceedingly great, yet all these substances are resolvable into a very small number of bodies. As an illustration, I shall take a well-known substance, common green copperas, or, as the chemists term it, protosulphate of iron. By submitting this compound to the process termed chemical analysis, two other kinds of matter may be obtained from it, namely, oxide of iron and oil of vitrol, or sulphuric acid. If we continued this process—if we submitted the acid and the oxide to analysis—we could separate the former into sulphur and oxygen, and the latter into iron and oxygen. Now, by these means we could

demonstrate the compound nature of copperas; we could prove that it was *proximately* composed of sulphuric acid and oxide of iron; and, *ultimately*, of iron, sulphur, and oxygen.

Iron, sulphur, and oxygen, are elementary, or simple bodies. They cannot be decomposed; they cannot be analysed. Torture them as we will in our crucibles; expose them as we please to the highest temperature of a wind furnace, or to the more intense heat evolved by a powerful galvanic battery; subject them to the influence of any agent, or force, or process we may choose, and still they will yield nothing but iron, sulphur, and oxygen: hence these undecomposable bodies are regarded as *elements*, or simple substances. So far as our knowledge extends, there are about sixty-six of these undecomposable bodies, of which about one half occurs in but exceedingly minute quantities, and a considerable number of the others exists in comparatively small amounts. As by far the greater proportion of compounds is made up of two or more of about a dozen elementary bodies, it would at first sight appear as if the distinct kinds of compounds which exist, or which may be called into existence by the chemist, must be limited to, at most, a realisable number; but the fact is there is no practical limit to the variety of substances which may be artificially formed. Every difference in the mode of the arrangement of the constituent atoms of a compound, causes its metamorphosis into another kind of substance. To prove that the number of these changes is bounded by no narrow limits, I need but refer to the rules of Permutation, which demonstrate that twelve letters of the alphabet may be arranged in no fewer than 479,000,000 different ways.* The elements are the letters of

* If the elements were only capable of combining with each other in simple ratios, the number of their combinations would be as limited as that of the letters of the alphabet; but as one, two, or more atoms of oxygen can combine with one, two, or more atoms of other elements, we can assign no limits to the number of *possible* combinations. There are hundreds o distinct substances formed of but two elements, namely, hydrogen and carbon.

Nature's alphabet, their compounds are the words of the language of Creation. The combinations of sounds and of signs which express the ideas and sensations of man may be limited to millions; but numberless are the hieroglyphs by which the Divine wisdom and beneficence is inscribed on the pages of the magnificent volume of Nature.

Of the sixty-six elementary bodies, not more than a dozen occur commonly in animal and vegetable substances; these are Oxygen, Hydrogen, Nitrogen, Carbon, Sulphur, Phosphorus, Chlorine, Silicium, Potassium, Sodium, Calcium, Magnesium, and Iron. In addition to these, Iodine, and sometimes Bromine, are found in plants which grow in or near the sea; and the former element has also been detected in some of the lower animals, and in land plants. Manganese, Lithium, Cæsium, Rubidium, and a few others of the simple bodies, occasionally occur in plants and animals, but I believe their presence therein is always accidental.

Proximate Composition of Animal Substances.—The differences between vegetable and animal substances are often more apparent than real. Indeed many of the more important of these substances are almost identical in composition. The albumen which coagulates when the juices of vegetables are boiled, is identical with the albumen of the white of eggs; the fibrine of wheat is in no respect chemically different from the fibrine, or clot, of the blood; and, lastly, the legumine, or *vegetable caseine*, of peas is almost undistinguishable from the curd of milk, or *animal caseine*. But not only has chemical research demonstrated the identity of the albumen, fibrine, and caseine of vegetables with three of the more important constituents of animals, it has gone a step further, and proved that they differ from each other in but a few unimportant respects. They are unquestionably convertible into each other* within

* In a paper by Professor Sullivan, of Dublin, the conversion of one of these substances into another *outside* the animal mechanism, is almost incontrovertibly proved.

the animal organism; and their functions, as elements of nutrition, are almost, if not quite, identical.

Exclusive of the blood, which contains the elements of every part of the body, the animal organism is composed of three distinct classes of substances—namely, *nitrogenous*, *non-nitrogenous*, and *mineral*. All of these constituents, or substances capable of being converted into them, must exist in the food. Certain articles, for example, milk, contains all of them; but in others, for instance, butter, only one of these substances is found. The nitrogenous part of the body embraces the muscles, or lean flesh, the gelatine of the bones, and the skin and its appendages—such as hair and horns; the non-nitrogenous constituents are its fat and oil; and its mineral matter is found chiefly in the bony framework. These constituents are not, however, isolated: the mineral matter, no doubt, accumulates in certain parts, but in small quantities it is found in every portion of the body; and although the fat forms a distinct tissue, the muscles of the leanest animal are never free from a sensible proportion of it.

Albumen, fibrine, and caseine are the principal nitrogenous constituents of food, and as they are employed in the reparation of the nitrogenous tissues of the animal body, they have been termed *flesh-formers*.

The fat and oil of animals are derived either from vegetable oil and fat, or from some such substance as starch or sugar. The constituents of food which form fat are termed *fat-formers;* and sometimes *heat-givers* or *respiratory elements*, from the notion that their slow combustion in the animal body is the chief cause of its high temperature.

The mineral elements of the body are furnished principally by the varieties of food which contain nitrogen. The whey of milk is rich in them; but they do not exist in pure butter, in starch, or in sugar.

Fat is a much more abundant constituent of the animal body than is generally supposed. That this substance should

constitute the greater portion of the weight of an obese pig seems probable enough; but few are aware that even in a lean sheep there is 50 per cent. more fat than lean.

For a very accurate knowledge of the relative proportions of the fatty, nitrogenous, and mineral constituents of the carcasses of animals used as human food, we are indebted to Messrs. Lawes and Gilbert. Before these investigators turned their attention to this subject, it had scarcely attracted the notice of scientific men; but a notion appears to have been current, amongst non-scientific people, at least, that in all, save the fattest animals, the lean flesh greatly preponderated over the fat. That this idea was unsustained by a foundation of fact, has been clearly proved by the results of an investigation* undertaken a few years ago by Messrs. Lawes and Gilbert—an investigation which I cannot avoid characterising as one of the most laborious and apparently trustworthy on record. The mere statement of the results of this inquiry occupies 187 pages of one of the huge volumes of the Transactions of the Royal Society—a fact which best indicates the immensity of the labour which these gentlemen imposed upon themselves, and which, independently of their other and numerous contributions to scientific agriculture, entitles their names to most honourable mention in the annals of science.

I shall now briefly advert to a few of the more important facts established by Lawes and Gilbert. From a large number of oxen, sheep, and pigs, on which feeding experiments were being conducted, ten individuals were selected. These were, a fat calf, a half-fat ox, a moderately fat ox, a fat lamb, a store sheep, a half-fat old sheep, a fat sheep, a very fat sheep, a store pig, and a fat pig. These animals were

* *Experimental Inquiry into the Composition of some of the Animals Fed and Slaughtered as Human Food.* By John Bennet Lawes, F.R.S., F.C.S., and Joseph Henry Gilbert, Ph.D., F.C.S. *Philosophical Transactions of the Royal Society.* Part II., 1860.

killed, and the different organs and parts of their bodies were separately weighed and analysed. The results were, that, with the exception of the calf, all the animals contained, respectively, more fat than lean. The fat ox and the fat lamb contained each three times as much fat as lean flesh, and the proportion of the fatty matters to the nitrogenous constituents of the carcass of the very fat sheep was as 4 to 1. In the pig the fat greatly preponderated over the lean; the store pig containing three times as much, and the fat pig five times as much fat as lean.

That part of the animal which is consumed as food by man, is termed the *carcass* by the butcher, and contains by far the greater portion of the fat of the animal. The *offal*, in the language of the butcher, constitutes those parts which are not commonly consumed as human food, at least by the well-to-do classes. In calves, oxen, lambs, and sheep, the offal embraces the skin, the feet, and the head, and all the internal organs, excepting the kidneys and their fatty envelope. The offal of the pig is made up of all the internal organs, excepting the kidneys and kidney fat. It is the relative proportion of fat in the carcasses analysed by Lawes and Gilbert that I have stated; but as the nitrogenous matters occur in greatest quantity in the offal, it is necessary that the relative proportions of the constituents of the body, taken as a whole, should be considered. On an average, then, it will be found that a fat fully-grown animal will contain 49 per cent. of water, 33 per cent. of dry fat, 13 per cent. of dry nitrogenous matter—muscles separated from fat, hide, &c.—and 3 per cent. of mineral matter. In a lean animal the average proportions of the various constituents will be 54 per cent. of water, 25½ per cent. dry fat, 17 per cent. of dry nitrogenous substances, and 3½ per cent. of mineral matter. In the following table these proportions are set forth.

SUMMARY OF THE COMPOSITION OF THE TEN ANIMALS—SHOWING THE PER-CENTAGES OF MINERAL MATTER, DRY NITROGENOUS COMPOUNDS, FAT, TOTAL DRY SUBSTANCE, AND WATER.

1st. In Fresh Carcass. 2nd. In Fresh Offal (equal Sum of Parts, excluding Contents of Stomachs and Intestines). 3rd. In Entire Animal (Fasted Live-weight, including therefore the weight of Contents of Stomachs and Intestines).

Description of Animal.	Per cent. in Carcass.					Per cent. in Offal.					Per cent. in Entire Animal.					
	Mineral matter.	Dry nitrogenous compounds.	Fat.	Dry substance.	Water.	Mineral matter.	Dry nitrogenous compounds.	Fat.	Dry substance.	Water.	Mineral matter.	Dry nitrogenous compounds.	Fat.	Dry substance.	Contents of viscera.	Water.
Fat calf	4·48	16·6	16·6	37·7	62·3	3·41	17·1	14·6	35·1	64·9	3·80	15·2	14·8	33·8	3·17	63·8
Half-fat ox	5·56	17·8	22·6	46·0	54·0	4·05	20·6	15·7	40·4	59·6	4·66	16·6	19·1	40·3	8·19	51·5
Fat ox	4·56	15·0	34·8	54·4	45·6	3·40	17·5	26·3	47·2	52·8	3·92	14·5	30·1	48·5	5·98	45·5
Fat lamb...	3·63	10·9	36·9	51·4	48·6	2·45	18·9	20·1	41·5	58·5	2·94	12·3	28·5	43·7	8·54	47·8
Store sheep	4·36	14·5	23·8	42·7	57·3	2·19	18·0	16·1	36·3	63·7	3·16	14·8	18·7	36·7	6·00	57·3
Half-fat old sheep ...	4·13	14·9	31·3	50·3	49·7	2·72	17·7	18·5	38·9	61·1	3·17	14·0	23·5	40·7	9·05	50·2
Fat sheep	3·45	11·5	45·4	60·3	39·7	2·32	16·1	26·4	44·8	55·2	2·81	12·2	35·6	50·6	6·02	43·4
Extra fat sheep ...	2·77	9·1	55·1	67·0	33·0	3·64	16·8	34·5	54·9	45·1	2·90	10·9	45·8	59·6	5·18	35·2
Store pig...	2·57	14·0	28·1	44·7	55·3	3·07	14·0	15·0	32·1	67·9	2·67	13·7	23·3	39·7	5·22	55·1
Fat pig	1·40	10·5	49·5	61·4	38·6	2·97	14·8	22·8	40·6	59·4	1·65	10·9	42·2	54·7	3·97	41·3
Means of all	3·69	13·5	34·4	51·6	48·4	3·02	17·2	21·0	41·2	58·8	3·17	13·5	28·2	44·9	6·13	49·0
Means of 8 of the half-fat, fat, and very fat animals...	3·75	13·3	36·5	53·6	46·4	3·12	17·4	22·4	42·9	57·1	3·23	13·3	29·9	46·4	6·26	47·3
Means of 6 of the fat, and very fat animals	3·38	12·3	39·7	55·4	44·6	3·03	16·9	24·1	44·0	56·0	3·00	12·7	32·8	48·5	5·48	46·0

SECTION III.

USE OF FAT IN THE ANIMAL ECONOMY.

As fat forms so large a portion of the body, it is evident that the part it plays in the animal economy must be a most important one. The general opinion which prevails amongst scientific men as to its physiological functions was originated by the celebrated Liebig. According to his theory, the food of animals includes two distinct kinds of substances—*plastic** and *non-plastic*. The plastic materials are composed of carbon, hydrogen, oxygen, nitrogen, and a little sulphur and phosphorus. Albumen, fibrine, and casein are plastic elements of nutrition; they form the lean flesh, or muscles, the membranes, and cartilages, the gelatine of the bones, the skin, the hair, and, in short, every part of the body which contains nitrogen. The *non-plastic* elements of nutrition include fat, oil, starch, sugar, gum, and certain constituents of fruits, such as pectine.

All non-plastic substances—and of each kind there are numerous varieties—are capable of conversion, in the animal mechanism, into fat and oil. The non-plastic food substances do not contain nitrogen, hence they are commonly termed non-nitrogenous elements. The oily and fatty matters contain a large proportion of carbon, their next most abundant component is hydrogen, and they contain but little oxygen. Unlike the plastic elements, they are—except the fats of the brain and nervous tissue—altogether destitute of sulphur and phosphorus. The starchy, saccharine, and gummy substances are composed of the same elements as the fatty bodies, but they contain a higher proportion of oxygen.

* From the Greek *plasso*, "to form." Plastic materials are sometimes termed *formative* elements; both terms imply the belief that they are capable of giving shape, or form, not only to themselves, but also to other kinds of matter not possessed of formative power.

According to Liebig, fat is used in the animal economy as a source of internal heat. We all know that it is a most combustible body, and that during its inflammation the most intense heat is developed. It is less evident, but not less true, that heat is evolved during its slow oxidation, or decay.

The more rapidly a body burns, the greater is the amount of heat evolved by it in a *given time;* but the total amount of heat developed by a specific weight of the body is the same, whether the combustion takes place rapidly or slowly. An experiment performed with phosphorus illustrates the case perfectly. If we burned two pieces of equal weight, the one in oxygen, the other in atmospheric air, we should find that the former would emit a light five times as brilliant as that evolved by the latter, for the simple reason that its combustion would be five times as rapid. The white, vapor-like matter into which phosphorus is converted by its combustion, is termed *phosphoric acid.* It is composed of phosphorus and oxygen. In forming an ounce of this compound, by the direct oxidation, or combustion of phosphorus, the amount of force, either as heat, or as heat and light, evolved is precisely the same, whether the time expended in the process be a minute or a month.* If, in the experiment I have described, we were to substitute two pieces of fat for the fragments of phosphorus, the results would be precisely similar. The fat burned in oxygen gas would emit intense light and heat; but the total amount of these forces evolved would be neither greater nor less than that developed during

* The slow conversion of phosphorus into phosphoric acid takes place in the animal organism; its gradual oxidation in the open air gives rise only to an imperfectly oxidised body—*phosphorous acid.* But the latter fact does not invalidate the general proposition, that the heat emitted by a substance undergoing the process of oxidation is proportionate to the amount of oxygen with which it combines, and is not influenced by the length of time occupied by the process, further than this, that if the oxidation be *very* rapidly effected, a portion of the heat will be converted into an *equivalent* amount of light.

the slower and therefore less brilliant combustion of the fat in ordinary atmospherie air. Now, as we can demonstrate that an ounce of fat will emit a certain amount of heat, if burned within a minute of time, and that neither a larger nor a smaller amount will be developed if the combustion of the fat extend over a period of five minutes, I think we may fairly assume that the amount of heat evolved by the complete oxidation of a specific quantity of fat is constant under all conditions, except, as I have already explained, at high temperatures, when a portion of the heat is converted into light.

In the animal organism fat is burned. The process of combustion no doubt is a very slow one, but still the total amount of heat evolved is just the same as if the fat were consumed in a furnace. When the fat constituting a candle is burned, what becomes of it? Its elements, carbon and hydrogen (we may disregard its small amount of oxygen) combine with the oxygen of the air, and form carbonic acid gas and water. What becomes of the fat consumed within the animal body? It also is converted into carbonic acid gas and water. It is not difficult to prove these statements to be facts. A candle will not burn in atmospheric air which has been deprived of its oxygen, because there is no substance present with which the elements of the taper can combine, consequently the process of combustion cannot go on. Now, a man may in one respect be compared with this taper. He is partly made up of fat; that fat is consumed by the oxygen of the air, and the heat developed thereby keeps the body warm. In the process of respiration oxygen is introduced into the lungs, and from thence, by means of the blood vessels, is conveyed throughout every part of the body. In some way, at present not thoroughly understood, the elements of the fat combine with the oxygen, and are converted into carbonic acid gas and water, which are exhaled from the lungs and from the surface of the body.

Fat is a constituent of both animals and plants. The animal derives a portion of its fat directly from the vegetable;

but it possesses the power of forming this substance from other organic bodies, such, for example, as starch. Plants elaborate fat directly from the minerals—carbonic acid gas, and water.

I have already explained that the growth of plants is, *cæteris paribus*, directly proportionate to the amount of sunlight to which they are exposed. Not less certainly is the force which constitutes the sun-beam expended in grouping mineral atoms into organic forms, than is the heat which converts water into steam. But in neither case is the force destroyed. When the vaporous steam is condensed into the liquid water, all the heat is restored, and becomes palpable. By the ultimate decomposition of vegetable substances all the force expended on their production is liberated, and, in some form, becomes manifest.

When the fat formed in the mechanisms of plants is decomposed in the animal organism, two results follow:—The atoms of the fat are re-converted to their original mineral, or statical conditions of carbonic acid gas and water; and the force which maintained them in their organic state is set free as heat, and its equivalent, motive power.

One of the most useful instruments which the ingenuity of man has devised, is the Thermometer. It is so familiarly known that I need not describe it. This instrument does not enable us to estimate the actual quantity of heat contained in a substance, but it indicates the proportion of that subtile element which is *sensible*—that is recognisable by the sense of touch. The dusky Hindu, clad in his single cotton garment, and the Laplander in his suit of fur, are placed under the most opposite conditions in relation to the heat of the sun—the Indian is exposed during the whole year to Sol's most ardent beams, whilst but a scant share of its genial rays goes to warm the body of the Laplander. Now, if we placed the bulb of a thermometer beneath the tongue of a Hindu, we would find the mercury to stand at 98 degrees on Fahrenheit's scale, and if we repeated the experiment

on a Laplander, we would obtain an identical result. Numerous experiments of this nature have been made on individuals in most parts of the world, and the results have proved that the temperature of the blood of man is 98 degrees Fahrenheit, whether he be in India or at Nova Zembla, on the *steppes* of Russia, or the elevated *plateaus* of America. This invariability* of the temperature of the bodies of men and of all other warm-blooded animals, appears the more wonderful when it it is considered that the range of the temperature of the medium in which they exist exceeds 200 degrees Fahrenheit. In India, the mercury in the thermometer has been observed to stand at 145 degrees in the direct sunlight, and at 120 degrees in the shade. In high latitudes the temperature is sometimes so low as 100 degrees below zero. A Russian army, in an expedition to China, in 1839, was exposed for several successive days to a temperature of 42 degrees below zero, and suffered severely in consequence.

The facts which I have cited clearly prove that the animal body possesses the power of generating, or, to speak more correctly, liberating heat, either from portions of its own mechanism or from substances placed within that mechanism.

At one time it was the general belief amongst physiologists that one portion of the food consumed by an animal was employed in repairing the waste of its body, and the remaining part was burned as fuel, evolving heat just in the same way as if it had been consumed in a furnace. It was this theory that led to the classification of food into flesh-formers, and heat-givers. It is now doubted if any portion of the food be really burned in this way; and I, for one, think it far more probable that, before its conversion into carbonic acid gas and water (whereby, according to this theory, it develops the heat which keeps the body warm), it first becomes assimilated, that is,

* This statement is not absolutely correct, but the range of variation is confined within such narrow limits as to be quite insignificant.

becomes an integral part of the animal body—blood, fat, muscle. Perhaps we would be nearer the truth if we were to assume that heat is evolved during the decomposition of both the nitrogenous and fatty constituents of the body.

The constantly recurring contractions of the muscles must alone be a source of much heat. The development of animal motive power is said to be strictly proportionate to the amount of muscular tissue decomposed. As the nitrogen of the latter is almost completely excreted under the form of urea, the quantity of the latter daily eliminated from the body of an animal is a measure of the decomposed muscular tissue, and consequently of the amount of muscular power generated in the animal organism.* The correspondence between the amount of the motive power of an animal, and the quantity of effete nitrogen excreted from the body, is limited to laboring men and to the lower animals. Strange as it may appear, it is an incontrovertible fact that men whose pursuits require the constant exercise of the intellectual faculties—lawyers, writers, statesmen, students, scientific men, and other brain-workers—excrete more urea than do men engaged in the most physically laborious occupations. An activity of thoughts and ideas involves a corresponding destruction of the tissues, and these require, for their reparation, the consumption of food. Here, then, we have a physical meaning for the common expression—" food for thought."

That the amount of heat developed in the animal organism, is proportionate to the quantity of fatty matters (or of substances capable of forming them) supplied to it in the shape of food, is a proposition which admits of easy demonstration. The natives of warm regions do not require the generation of much heat within their bodies, because the temperature of the medium in which they exist is generally as high as, or higher than, that of their blood. But as they must consume food for

* Doubt has recently been thrown on the truth of this belief by Frankland, Fick, and Wislicenus.

the purpose of repairing the waste of their nitrogenous tissues, and as every kind of food contains heat-producing elements, an excess of heat is developed within their bodies, which, if allowed to accumulate, would speedily produce fatal results. The means by which nature removes this superabundant heat are admirably simple, as indeed all its contrivances are. The skin is permeated with millions of pores, and through these openings a large quantity of vapor is given off, and carries with it the surplus heat. The pores are the orifices of minute convoluted tubes which lie beneath the skin, and when straightened measure each about the tenth of an inch, or, according to a writer in the *British and Foreign Medico-Chirurgical Review* (1859, page 349), the one-fifteenth of an inch in length. According to Erasmus Wilson, the number of these tubes which open into every square inch of the surface of the body is 2,800. The total number of square inches on the surface of an average sized man is 2,500, consequently the surface of his body is drained by not less than twenty-eight miles of tubing, furnished with 7,000,000 openings. The cooling of the body, by the evaporation of water from it, admits of explanation by well-known natural laws. Water, in the state of vapor, occupies a space 1,700 fold greater than it does in its liquid condition. It is heat which causes its vaporous form, but it ceases to be heat when it has accomplished this change in the condition of the liquid; for, suffering itself an alteration, it passes into another form of force—mechanical, or motive power. The heat generated within the body is absorbed by the liquid water, the conversion of the latter into vapor follows, and both the heat and the water, in their altered forms, escape through the pores.

Fatty food necessary in cold climates.—As a grave objection against the chemical theory of heat, it has been urged that rice—the pabulum of hundreds of millions of the inhabitants of tropical regions—contains an exceedingly high proportion of heat-giving substances. I have, however, great doubt as to rice ever forming the exclusive food of those people, without

their health being impaired in consequence of the deficiency in that substance of the plastic elements of nutrition. Indeed I believe it is a great mistake to assert that the natives of India live almost exclusively on rice. This article, no doubt, forms a large proportion of their food, but it is supplemented with pulse (the produce of leguminous plants), which is rich in flesh-forming materials, also with dried fish, butter, and various kinds of vegetable and animal food rich in nitrogen. The innutritious nature of rice is clearly shown by its chemical composition, and so large a quantity of it must the Hindu consume in order to repair the waste of his body, that his stomach sometimes acquires prodigious dimensions; hence the term "pot-bellied," so often applied to the Indian ryot. I doubt very much, however, if the stomach of the Hindu, large as it is, could accommodate a quantity of rice, the combustion of which would produce a very excessive development of heat. This substance, when cooked, contains a high proportion of water, the evaporation of which carries off a large amount of the heat generated by the combustion of its respiratory constituents. The amount of motive power developed by the Hindu is small as compared with that which the European is capable of exerting; hence he has less necessity for a highly nitrogenous diet. On the whole, then, I am disposed to think that the food of the natives of tropical climates contains sufficient nitrogenous matters to effectually build up and keep in repair their bodies; it also appears clear to me that the amount of heat developed in their bodies is not excessive, and that it is readily disposed of in converting the water, which enters so largely into their diet, into vapor. The proportion of plastic to non-plastic elements in the diet of the Hindu and of the well-fed European, is probably as follows:—

	Nitrogenous.		Non-nitrogenous (calculated as starch.)
Hindu	1	to	9
European	1	to	8

This statement does not quite correspond with Liebig's, who estimates the proportion of nitrogenous to non-nitrogenous substances in rice as 10 to 123, in beef as ten to seventeen, and in veal as ten to one. The results of Lawes and Gilbert's investigations, already alluded to, have, however, dispelled the illusion that the plastic constituents of flesh exceed its non-plastic. In the potato, which at one time constituted more of the food of the Irish peasantry than rice does that of the Hindu, the proportion of plastic to non-plastic materials is as 10 to 110. The results of some analyses of the food grains consumed in the Presidency of Madras, made by Professor Mayer, of the University of Madras, clearly prove that the food of the inhabitants of that part of India is of a far more highly nitrogenous character than is generally supposed. That the Hindu, who subsists exclusively on rice, exhibits all the symptoms of deficient nutrition, is a fact to which numerous competent observers have testified.

A slight consideration of the facts which I have mentioned leads to the conclusion that the food of the inhabitants of very cold regions is required to produce a large amount of heat. Melons, rice, and other watery vegetable productions, however delicious to the palate of the Hindu, would be rejected with disgust by the Esquimaux, whilst the train oil, blubber, and putrid seal's flesh which the children of the icy North consider highly palatable, would excite the loathing of the East Indian. On this subject I may appositely quote the following remarks by Dr. Kane, the Arctic explorer :—"Our journeys have taught us the wisdom of the Esquimaux appetite, and there are few among us who do not relish a slice of raw blubber, or a chunk of frozen walrus beef. The liver of a walrus (awuktanuk), eaten with little slices of his fat—of a verity it is a delicious morsel. Fire would seem to spoil the curt, pithy expression of vitality which belongs to its uncooked juices. Charles Lamb's roast pig was nothing to awuktanuk. I wonder that raw beef is not eaten at home. Deprived of extraneous fibre, it is neither indigestible nor difficult to masticate. With acids

and condiments, it makes a salad which an educated palate cannot help relishing; and as a powerful and condensed heat-making and anti-scorbutic food, it has no rival. I make this last broad assertion after carefully considering its truth. The natives of South Greenland prepare themselves for a long journey, by a course of frozen seal. At Upper Navik they do the same with the narwhal, which is thought more heat-making than the seal; while the bear, to use their own expression, is 'stronger travel than all.' In Smith's Sound, where the use of raw meat seems almost inevitable from the modes of living of the people, walrus holds the first rank. Certainly this pachyderm (Cetacean?) whose finely condensed tissue and delicately permeating fat (oh! call it not blubber) assimilate it to the ox, is beyond all others, and is the best *fuel* a man can swallow." The gastronomic capabilities of the Esquimaux and of other northern races, and their fondness for fatty food, are exhibited in a sufficiently strong light in the following statements:—

Captain Parry weighed and presented to an Esquimaux lad the following articles:—

	lb.	oz.
Frozen seahorse flesh	4	4
Wild seahorse flesh	4	4
Bread and bread dust	1	12
Rich gravy soup	1	4
Water	10	0
Strong grog	1 tumbler.	
Raw spirits	3 wine glasses.	

This large quantity of food, which the lad did not consider excessive, was consumed by him within twenty-four hours. According to Captain Cochrane a reindeer suffices but for one repast for three Yakutis, and five of them will devour at a sitting a calf weighing 200lbs. Mr. Hooper, one of the officers of the *Plover*, in his narrative of their residence on the shores of Arctic America, states that "one of the ladies who visited them was presented, as a jest, with a small tallow

candle, called a purser's dip. It was, notwithstanding, a very pleasant joke to the damsel, who deliberately munched it up with evident relish, and finally drew the wick between her set teeth to clean off any remaining morsels of fat."

The partiality for certain kinds of food, and disgust at other varieties, which particular races of men exhibit, is an instinct which they cannot avoid obeying. Instead of exciting our disgust, as it too frequently does, it should exalt our admiration of the infinite wisdom of the Creator, who by simply adapting man's desire for particular kinds of food to the external conditions under which he is placed, enables him to occupy and "subdue the earth" from the Equator to the Poles.

The food of human beings and of the lower animals who inhabit cold countries is nearly exclusively composed of animal substances. The flesh, fat, and oil of animals occupy less space than do the corresponding elements of vegetables; consequently the nutriment they afford is more concentrated, and a larger quantity can be stowed away without inconvenience in the stomach. The heat-forming constituents of these substances constitute not only the chief part of their bulk, but they are also capable of evolving a greater amount of heat than any other of the respiratory elements. One pound of dry fat will develop as much heat as two and a half pounds of dry starch, and the fattest flesh includes four times as much plastic materials as rice. The diet of people all over the world, unless under circumstances which prevent the gratification of the natural appetite, establishes the intimate relation which subsists between cold and food. The appetite of man is at a minimum at the Equator, and at a maximum within the Arctic circle. The statements as to the voracity of Hottentots and Bosjesmans, recorded in the narratives of travellers, do not in the slightest degree affect the general rule that more is eaten in cold climates than in hot regions. These are mere records of gluttony, and it would not be difficult to find parallel cases in our own country. Gluttony is an abnormal appetite, and the

greater part of the food devoured under its unnatural, and generally unhealthy stimulus is not applied to the wants of the body.

The bodies of animals are heated masses of matter, and are subject to the ordinary laws of *radiation*. Every substance radiates its heat, and receives in return a portion of that emitted from surrounding bodies. If two bodies of unequal temperature be placed near each other, the warmer of the two will radiate a portion of its heat to the colder, and will receive some of the heat of the latter in return; but as the warmer body will emit more heat than it will receive, the result will be, that after a time, the length of which will depend on the nature of the bodies, both will acquire the same temperature. In very warm climates the bodies of animals derive from the sun, and from the heated bodies surrounding them, more heat than they give in return; and were it not for their internal cooling apparatus, which I have described, the heat so absorbed would prove fatal. In every climate, on the contrary, where the temperature is lower than 98°, or "blood heat," the bodies of animals lose more heat by radiation than they receive by the same means. The philosophy of the *clothing* of men and the *sheltering* of the lower animals is now evident. It is not only necessary that heat should be developed within the body, but also that its wasteful expenditure should be prevented. The latter is effected by interposing between the warm body and the cold air some substances (such as fur or wool) which do not readily permit the transmission of heat—*non-conductors* as they are termed. The close down of the eider duck is destined to protect its bosom from the chilling influence of the icy waters of the North Polar Sea, and the quadrupeds of the dreary Arctic Circle are sheltered by thick fur coverings from the piercing blasts of its long winter.

Fat Equivalents.—Whilst it is quite certain that neither nerves nor muscles can be elaborated exclusively out of fat, starch, sugar, or any other non-nitrogenous substance, it is almost equally clear that fat may be formed out of nitrogenous

tissue. The quantity of fat, however, which is produced in the animal mechanism, from purely nitrogenous food appears to be relatively very small. No animal is capable of subsisting solely on muscle-forming materials, no matter how abundantly supplied. The food of the Carnivora contains a large proportion of fat, and the nutriment of the Herbivora is largely made up of starch and other fat-formers. Dogs, geese, and other animals fed exclusively upon albumen or white of egg rapidly decreased in weight, and after presenting all the symptoms of starvation, died in three or four weeks.* The fat of the bodies of the Carnivora is almost entirely formed—and probably with little if any alteration—from the fatty constituents of their food. Herbivorous animals, on the contrary, derive nearly all their fat from starch, sugar, gum, cellulose, and other non-nitrogenous, but not fatty, materials.

Although starch is convertible into fat, it is not to be understood that a pound weight of one of these bodies is equivalent to an equal quantity of the other. During the conversion of starch into fat, the greater number of its constituent atoms is converted into water and carbonic acid gas. The greater number of the more important metamorphoses of organised matter, which take place in the animal organum, is the result of either oxidation or fermentation : in the conversion of starch or sugar into fat or oil, both of these processes, it is stated, take place ; a portion of the hydrogen is converted by oxidation into water, and by fermentation carbonic acid gas is formed, which removes both oxygen and carbon. Perhaps in the formation of fat fermentation is alone employed—a portion of the oxygen being removed as water, and another portion as carbonic acid. The chief difference between the ultimate composition of starch

* The results of Savory's experiments on rats appear to prove that animals can live on food destitute of fat, sugar, starch, or any other fat-forming substance. I think, however, that animals could hardly thrive on purely nitrogenous food. The conclusions which certain late writers, who object to Liebig's theory of animal heat, have deduced from Savory's investigations, appear to me to be quite unfounded.

and fat is, that the latter contains a much larger proportion of hydrogen and carbon. The knowledge of the exact quantity of starch required for the formation of a given amount of fat is of importance in enabling us to estimate the relative feeding value of both substances. Certain difficulties stand in the way of our acquiring an accurate knowledge on this point. Not only are there several distinct kinds of fat, but the precise formula, or atomic constitution of each, is as yet veiled in doubt. There are three fats which occur in man and the domesticated animals, and in vegetables. These are stearine, margarine, and oleine. The relative proportions of these vary in each animal: thus, in man and in the goose margarine is the most abundant fat, whilst oleine* exists in the pig in a greater porportion than in man, the sheep, or the ox. The composition of the animal fats does not, however, vary much; and this fact, together with other considerations, have led chemists to assume that two-and-a-half parts of starch are required for the production of one part of the mixed fats of the different animals. Grape sugar and the pectine bodies — substances which form a large proportion of the food of the Herbivora—contain more oxygen and hydrogen than exist in starch, and, consequently, are not capable of forming so large an amount of fat as an equal weight of starch. We may assume, then, that 2·50 parts of starch, 2·75 parts of sugar, or 3 parts of the pectine bodies, are equivalent to 1 part of fat.

SECTION IV.

RELATION BETWEEN THE COMPOSITION OF AN ANIMAL AND THAT OF ITS FOOD.

I HAVE already stated that the results of the admirable investigations of Lawes and Gilbert prove that the non-nitro-

* So termed because it is the basis of the common oils; the fluid portion of fat is composed of oleine.

genous constituents of the carcasses of oxen, sheep, and pigs exceed in weight their nitrogenous elements. This fact is suggestive of many important questions. What relation is there between the composition of an animal and that of its food? Should an animal whose body contains three times as much fat as lean flesh, be supplied with food containing three times as much fat-formers as flesh-formers? To these questions there is some difficulty in replying. There *is* a relationship between the composition of the body of an animal and that of its food; but the relationship varies so greatly that it is impossible to determine with any degree of accuracy the quantity of fat-formers which is required to produce a given weight of fat in animals, taken *in globo*. If, however, we deal with a particular animal placed under certain conditions, it is then possible to ascertain the amount of fat which a given weight of non-plastic food will produce. For the greater part of our knowledge on this point, as on so many others, in the feeding of stock, we are indebted to Lawes and Gilbert. In the case of sheep fed upon fattening food these inquirers found that every 100lbs. of dry* non-nitrogenous substances consumed by them produced, on an average, an increase of 10lbs. in the weight of their fat. In the case of pigs, also, supplied with food, the proportion of non-nitrogenous matters appropriated to the animal's increase was double that so applied in the bodies of the sheep. As the food supplied to these animals contained but a very small proportion of ready-formed fat, it was inferred that four-fifths of the fat of the increase was derived from the sugar, starch, cellulose, and pectine bodies.

These tables exhibit in a condensed form the results of one of the elaborate series of experiments in relation to this point carried out by Lawes and Gilbert:—

* The term *dry* is applied to the *solid* constituents of the food. Thus, a pig fed with 100lbs. of potatoes would be said to have been supplied with 25lbs. of dry potatoes, because water forms 75 per cent. of the weight of those tubers.

ESTIMATED AMOUNT OF CERTAIN CONSTITUENTS STORED UP IN *INCREASE*, FOR 100 PARTS OF EACH CONSUMED IN FOOD BY FATTENING SHEEP.

General Particulars of the Experiments.						Amount of each Class in Increase for 100 of the same consumed in Food.			
Breed.	No. of Animals.	Duration.		Description of Fattening Food. Given in limited quantity.	Description of Fattening Food. Given ad libitum.	Mineral matter (ash).*	Nitrogenous compounds (dry).	Non-nitrogenous substance.	Total dry substance.
Class I.									
		wks.	dys.						
Cotswolds	46	19	5	Oilcake and clover chaff	Swedish turnips.	3·98	4·43	11·6	9·60
Leicesters	40	20	0	Oilcake and clover chaff	Swedish turnips.	3·15	3·39	12·0	9·48
Cross-bred wethers	40	20	0	Oilcake and clover chaff	Swedish turnips.	3·24	3·60	11·6	9·31
Cross-bred ewes ...	40	20	0	Oilcake and clover chaff	Swedish turnips.	3·25	3·60	11·8	9·40
Hants Downs ...	40	26	0	Oilcake and clover chaff	Swedish turnips.	3·40	4·28	10·3	8·49
Sussex Downs ...	40	26	0	Oilcake and clover chaff	Swedish turnips.	3·30	4·16	10·3	8·44
Means						3·39	3·91	11·3	9·12
Class III.—(Series 1.)									
Hants Downs ...	5	13	6	Oilcake ...	Swedish turnips	4·16	4·01	11·1	9·33
	5	13	6	Oats	Swedish turnips	5·73	7·07	10·0	9·45
	5	13	6	Clover chaff	Swedish turnips	3·98	7·44	9·0	8·49
Means						4·62	6·17	10·0	9·09
Class IV.—(Series 2.)									
Hants Downs ...	5	19	1	Oilcake ...	Clover chaff.	1·69	2·20	6·3	5·07
	5	19	1	Linseed ...	Clover chaff.	1·81	2·32	6·2	5·19
	5	19	1	Barley ...	Clover chaff.	1·75	2·82	5·7	5·00
	5	19	1	Malt	Clover chaff.	1·46	2·17	5·3	4·61
Means						1·68	2·38	5·9	4·97

* The amounts of "mineral matter" are too high, owing to the adventitious matters (dirt) retained by the wool.

General Particulars of the Experiments.					Amount of each Class in Increase for 100 of the same consumed in Food.			
Breed.	No. of Animals.	Duration.	Description of Fattening Food. Given in limited quantity.	Description of Fattening Food. Given ad libitum.	Mineral matter (ash).*	Nitrogenous compounds (dry).	Non-nitrogenous substance.	Total dry substance.
Class V.—(Series 4.)								
		wks. dys.						
Hants Downs ...	4	10 0	Barley ground	Mangolds.	3·80	5·65	9·8	8·91
	5	10 0	Malt, ground, & malt dust.		4·04	6·18	10·4	9·49
	4	10 0	Barley ground and steeped.		3·72	6·35	8·9	8·28
	4	10 0	Malt, ground and steeped, & malt dust.		2·95	4·34	9·3	8·23
	5	10 0	Malt, ground, & malt dust.		3·46	5·46	9·1	8·25
Means					3·59	5·60	9·5	8·63
Means of all					3·27	4·41	9·4	8·06

ESTIMATED AMOUNT OF CERTAIN CONSTITUENTS STORED UP IN *INCREASE*, FOR 100 OF EACH CONSUMED IN FOOD, BY FATTENING PIGS.

General Particulars of the Experiments.				Amount of each Class in Increase for 100 of the same consumed in Food.				
No. of Animals.	Duration.	Description of Fattening Food. Given in limited quantities.	Description of Fattening Food. Given ad libitum.	Mineral matter (ash).	Nitrogenous compounds (dry).	Non-nitrogenous substance.	Total dry substance.	Fat.
The Analysed "Fat Pig."†								
1	weeks 10	Mixture of bran 1, bean and lentil-meal 2, and barley-meal 3 parts, ad libitum		2·66	7·76	17·6	14·9	405

* The amounts of "mineral matter" are too high, owing to the adventitious matters (dirt) retained by the wool.

† This pig was completely analysed by Lawes and Gilbert.

General Particulars of the Experiments.				Amount of each Class in Increase for 100 of the same consumed in Food.				
No. of Animals.	Duration.	Description of Fattening Food. Given in limited quantities.	Description of Fattening Food. Given ad libitum.	Mineral matter (ash).	Nitrogenous compounds (dry).	Non-nitrogenous substance.	Total dry substance.	Fat.
Series I.								
3	weeks 8	None...	Bean & lentil-meal.	0·68	4·88	25·3	17·5	621
3		Indian-meal		1·86	6·39	23·7	17·9	477
3		Indian-meal and bran		0·33	5·02	21·1	16·1	362
3		None...	Indian-meal	2·09	9·28	20·9	18·6	300
3		Bean and lentil-meal		0·99	9·18	20·9	18·4	324
3		Bran		2·35	12·10	20·3	18·7	300
3		Bean, lentil-meal, and bran.		2·71	10·03	21·3	18·5	307
3		Bean, lentil-meal, Indian-meal, bran, ad libitum.		0·22	5·65	21·1	16·8	362
		Means		0·74	7·82	21·8	17·8	382
Series II.								
3	8	None...	Bean & lentil-meal.	3·20	3·12	26·5	18·2	801
3		Barley-meal		0·16	4·65	19·2	14·7	575
3		Bran		0·16	3·99	21·2	15·2	547
3		Barley-meal and bran		0·75	4·57	20·1	15·6	514
3		None...	Barley-meal	0·56	10·09	18·5	16·9	574
3		Bean and lentil-meal		0·53	6·57	21·1	17·5	620
3		Bran		0·49	9·79	18·9	16·9	506
3		Bean, lentil-meal, and bran.		4·33	4·49	22·7	18·0	578
6		Mixture of bran 1, barley-meal 2, and bean lentil-meal 3 parts, ad libitum.		0·27	5·65	20·4	16·1	495
6		Mixture of bran 1, bean lentil-meal 2, barley-meal 3 parts, ad libitum.		1·58	8·10	21·1	17·6	515
		Means		0·59	6·10	21·0	16·7	572
Series III.								
4	8	Dried Cod Fish ...	Bran & Indian-meal (equal parts).	1·06	5·06	24·3	18·1	315
4			Indian-meal ...	0·26	8·16	25·6	20·9	352
		Means		0·66	6·61	24·9	19·5	333

General Particulars of the Experiments.				Amount of each Class in Increase for 100 of the same consumed in Food.				
No. of Animals.	Duration.	Description of Fattening Food. Given in limited quantities.	Description of Fattening Food. Given ad libitum.	Mineral matter (ash).	Nitrogenous compounds (dry).	Non-nitrogenous substance.	Total dry substance.	Fat.
		Series IV.						
	weeks							
3	10	Lentil-meal & bran	Sugar	3·07	9·30	19·4	16·9	
3	10	Lentil-meal & bran	Starch	3·18	9·36	19·4	16·9	
3	10	Lentil-meal & bran	Sugar & starch	4·06	10·78	17·7	16·1	
3	10	Lentils, bran, sugar, starch, ad libitum.		4·80	9·96	18·7	16·5	
		Means		3·78	9·85	18·8	16·6	
		Means of all		0·58	7·34	21·2	17·3	472

The larger appropriation of the non-nitrogenous constituents of its food by the pig, as compared with the sheep, must not be attributed solely to its greater tendency to fatten, but partly to the far more digestible nature of the food supplied to it.

SECTION V.

RELATION BETWEEN THE QUANTITY OF FOOD CONSUMED BY AN ANIMAL, AND THE INCREASE IN ITS WEIGHT, OR OF THE AMOUNT OF ITS WORK.

The manifestations of that wondrous and mysterious principle, *life*, are completely dependent upon the decomposition of organised matter. Not an effort of the mind, not a motion of the body, can be accomplished without involving the destruction of a portion of the tissues. In a general sense we may regard the fat of the animal to be its store of fuel, and its lean flesh to be the source of its motive power. As the evolution of heat within the body is proportionate to the

quantity of fat consumed, so also is the amount of force developed in the animal mechanism in a direct ratio to the proportion of flesh decomposed. The quantity of fat burned in the body is estimated by the amount of carbonic acid gas expired from the lungs and perspired through the skin; the proportion of flesh disorganised is ascertained by the quantity of urea eliminated in the liquid egesta. The amount of urea excreted daily by a man is influenced by the activity of his mind, as well as by that of his body. A man engaged in physical labor wears out more of his body than one who does no work; and a man occupied in a pursuit involving intense mental application, consumes a greater proportion of his tissue than the man who works only with his body.* In each of these cases, there is a different amount of tissue disorganised, and consequently a demand for different amounts of food, with which to repair the waste. But all the food consumed by a man is not devoted to the reparation of the tissue worn out in the operations of thinking and working. A human being whose mind is a perfect blank, and who performs no bodily work, excretes a large quantity of urea, the representative of an equivalent amount of worn-out flesh. In fact the greater part of the food consumed by a man serves merely to sustain the functions of the body—the circulation of the blood—the action of the heart—the movements of the muscles concerned in respiration—in a word, the various motions of the body which are independent of the will. According to

* The results of recent and accurately conducted investigations prove that men engaged in occupations requiring the highest exercise of the intellectual faculties, require more nutritious food, and even a greater quantity of nutriment, than the hardest worked laborers, such as paviours, and navvies. I have been assured by an extensive manufacturer, that on promoting his workmen to situations of *greater* responsibility but *less* physically laborious than those previously filled by them, he found that they required more food and that, too, of a better quality. This change in their appetite was not the result of increased wages, which in most cases remained the same—the decrease in the amount of labour exacted being considered in most cases a sufficient equivalent for the increased responsibility thrown upon them.

Professor Haughton, about three-fourths of the food of a working man of 150 lbs. weight, are used in merely keeping him *alive*, the remaining fourth is expended in the production of mechanical force, constituting his daily toil.

In the nutrition of the lower animals, as in that of man, the amount of food made use of by a particular individual depends upon its age, its weight, the amount of work it performs, and probably its temper. As three-fourths of the weight of the food of a laboring man are expended in merely keeping him alive, it is obvious that the withholding of the remaining fourth would render him incapable of working. An amount of food which adequately maintains the vital and mechanical powers of three men, serves merely to keep four alive. It is the same with the horse, the ox, and every other animal useful to man: each makes use of a certain amount of food, *for its own purposes;* all that is consumed beyond that is applied for the benefit of its owner. Let us take the case of two of our most useful quadrupeds—the horse and the ox. The horse is used as an immediate source of motive power. For this purpose food is supplied to it, the greater portion of which is consumed in keeping the animal alive, and the rest for the development of its motive power. Abundance of food is as necessary to the natural mechanism, the horse, as fuel is to the artificial mechanism, the steam-engine. In each case the amount of force developed is, within certain limits, proportionate to the quantity of vegetable or altered vegetable matter consumed. The greater portion of the ox's food is also consumed in keeping its body alive, and the rest, instead of being expended in the development of motive power, accumulates as surplus stores of flesh, which in due time are applied to the purpose of repairing the organisms of men. It is evident then, that the greater sufferer from the deficient supply of food to animals is their owner. That they cannot be *taught* to *fast* is a fact which does not appear very patent to some minds. The man who sought by gradually reducing the daily quantum of his horse's provender to accus-

tom it to work without eating, was justly punished for his ignorant cruelty. The day before the horse's allowance was to be reduced to pure water, and when its owner's hope appeared certain of speedy realisation, the animal died. There are men who act almost as foolishly as the parsimonious horse owner in this fable did; and who are as properly punished as he was. Such men are to be found in the farmers who overstock their sheep pastures, and whose "lean kine" are the *laughing stock* of their more intelligent neighbours.

The weight of a working full-grown horse does not vary from day to day, as the weight of its egesta is equal to that of its food. The desideratum in the case of the working animal is that its food should be as thoroughly decomposed as possible, and the force pent up in it liberated within the animal's body: as an ox, on the contrary, increases in weight from day to day, it is desirable that as little as possible of its food should be disorganised. The wasteful expenditure of the animal's fat may be obviated by shelter, and the application of artificial heat: the retardation of the destruction of its flesh is even more under our control; for, as active muscular exertion involves the decomposition of tissue, we have merely to diminish the activity of the motions which cause this waste. This, in practice, is effected by stall-feeding. Confined within the narrow boundaries of the stall, the muscular action of the animal is reduced to a minimum, or limited to those uncontrollable actions which are conditions in the maintenance of animal life.

The proportion of the food of oxen, sheep, and pigs, which is consumed in maintaining their vital functions, has not been accurately ascertained; probably, as in the case of man, it is strictly proportionate to the animal's weight. We can determine the amount of plastic food consumed by an animal during a given period: we can ascertain the increase (if any) in the weight of its body; and finally, we can weigh and analyse its egesta. With these data it is comparatively easy to ascertain the quantity of food which produced the increase in

the animal's weight; but they do not enable us to determine the amount expended in keeping it alive, because the egesta might be largely made up of unappropriated food—organised matter which had done no work in the animal body. When we come to know the precise quantity of nitrogen, in a purely, or nearly pure, mineral form* excreted by an animal, then we shall be in a position to estimate the proportion of its food expended in sustaining the essential vital processes which continuously go on in its body. But although we are in ignorance as to the precise quantity of flesh-formers expended in keeping the animal alive, we know pretty accurately the amount which is consumed in producing a given weight of its flesh, or rather in causing a certain increase in its weight. This knowledge is the result of numerous investigations, of which by far the most valuable are those of Lawes and Gilbert. These experimenters found that fattening pigs stored up about 7½ per cent. of the plastic materials of their food, whilst sheep accumulated somewhat less than 5 per cent. That is, 92½ out of every 100 lbs. weight of the nitrogenous food of the pig, and 95 out of every 100 lbs. of that of the sheep, are eliminated in the excretions of those animals.

It appears from the results of Lawes and Gilbert's experiments, that pigs store up in their *increase* about 20 per cent., sheep 12 per cent., and oxen 8 per cent. of their (dry) food. The relative increase of the fatty, nitrogenous, and mineral constituents whilst fattening, are shown in this table.

Cases.	Estimated per cent. in Increase whilst Fattening.			
	Mineral matter (ash).	Nitrogenous matter (dry).	Fat (dry).	Total dry substance.
Average of 98 oxen	1·47	7·69	66·2	75·4
Average of 348 sheep	1·80	7·13	70·4	79·53
Average of 80 pigs	0·44	6·44	71·5	78·40

* As ammonia, urea, uric acid, or hippuric acid; all of which are nearly or perfectly mineralised subtances.

The quantity of food consumed daily by an animal is, as might be expected, proportionate to the weight of its body. The pig consumes, for every 100 lbs. of its weight, from 26 to 30 lbs. of food, the sheep 15 lbs., and the ox 12 to 13 lbs. These figures and the statements which I have made relative to the proportions of fat and plastic elements in the animals' bodies, apply to them in their fattening state, and when the food is of a highly nutritious character. The calf and the young pig will make use—to cause their increase—of a larger portion of nitrogenous matters. The sheep, however, being early brought to maturity, will, even when very young, store up the plastic and non-plastic constituents of its food, in nearly the same relative proportions that I have mentioned.

As it is the food taken into the body that produces heat and motion, it might at first sight appear an easy matter to determine the amount of heat or of motion which a given weight of a particular kind of food is capable of producing within the animal mechanism. But this performance is not so easy a task as it appears to be. In the first place, all of the food may not be perfectly oxidised, though thoroughly disorganised within the body; secondly, as animals rarely subsist on one kind of food, it is difficult, when they are supplied with mixed aliments, to determine which of them is the most perfectly decomposed. But though the difficulties which I have mentioned, and many others, render the task of determining the nutritive values of food substances difficult, the problem is by no means insoluble, and, in fact, is in a fair way of being solved. Professor Frankland, in a paper published in the number of the *Philosophical Magazine* for September, 1866, determines the relative alimental value of foods by ascertaining the quantity of heat evolved by each when burned in oxygen gas. From the results of these researches he has constructed a table, showing the amount of food necessary to keep a man alive for twenty-four hours. The following figures, which I select from this table, are of interest to the stock-feeder :—

Kinds of Food.	Weight necessary to sustain a man's life for twenty-four hours. Ounces.
Potatoes	13·4
Apples	20·7
Oatmeal	3·4
Flour	3·5
Pea Meal	3·5
Bread	6·4
Milk	21·2
Carrots	25·6
Cabbage	31·8
Butter	1·8
Lump Sugar	3·9

These figures show the relative calefacient, or heat-producing powers of the different foods named *outside* the body; but there is some doubt as to their having the same relative values when burned *within* the body. The woody fibre of the carrots and cabbages is very combustible in the coal furnace, but it is very doubtful if more than 20 or 30 per cent. of this substance is ever burned in the *animal furnace.* However, such inquiries as those carried out by Frankland possess great value; and tables constructed upon their results cannot fail to be useful in the drawing up of dietary scales, whether for man or for the inferior animals.

I may here remark, that in my opinion the nutritive value of food admits of being very accurately determined by the adoption of the following method:—

1. The animal experimented upon to be supplied daily with a weighed quantity of food, the composition and calefacient value of which had been accurately determined. 2. The gases, vapors, and liquid and solid egesta thrown off from its body to be collected, analysed, and the calefacient* value of the combustible portion of them to be

* The excrements of animals are capable of evolving, by combustion, enormous amounts of heat.

determined. 3. The increase (if any) of the weight of the animal to be ascertained. 4. The difference between the amount of heat evolvable by the foods before being consumed, and that actually obtained by the combustion of the egesta into which they were ultimately converted, would be the amount actually set free and rendered available within the body. The calculations would be somewhat affected by an increase in the weight of the animal's body; but it would not be difficult to keep the weight stationary, or nearly so, and there are other ways of getting over such a difficulty. An experiment such as this would be a costly one, and could not be properly conducted unless by the aid of an apparatus similar to that employed by Pettenkofer in his experiments on respiration. This apparatus, which was made at the expense of the King of Bavaria, cost nearly £600.

Value of Manure.—It is a complication in the question of the economic feeding of the farm animals that the value of their manure must be taken into account. Of the three classes of food constituents, two—the mineral and nitrogenous—are recoverable in the animal's body and manure; the non-nitrogenous is partly recoverable in the fat. I shall take the case of a sheep, which will consume weekly per 100 lbs. of its weight, 12 lbs. of fat-formers, and 3 lbs. of flesh-formers. Twelve per cent. of the fat-formers will be retained in the *increase*, but the rest will be expended in keeping the animal warm, and the products of its combustion—carbonic acid and water—will be useless to the farmer. It is, therefore, desirable to diminish as much as possible the combustion of fatty matter in the animal's body; and this is effected, as I have already explained, by keeping it in a warm place. Of the flesh-forming substance only five per cent. is retained in the increase, the rest is partly consumed in carrying on the movements of the animal—partly expelled from its body unaltered, or but slightly altered, in composition. The solid excrement of the animal contains all the undigested food; but of this only the mineral and nitrogenous constituents are valuable as

manure. The nitrogen of the plastic materials which are expended in maintaining the functions of the body is eliminated from the lungs, through the skin, and by the kidneys—perhaps also, but certainly only to a small extent, by the rectum.

The food consumed by an animal is disposed of in the following way :—A portion passes unchanged, or but slightly altered, through the body; another part is assimilated and subsequently disorganised and ejected; the rest is converted into the carcass of the animal at the time of its death. The undigested food and aliment which had undergone conversion into flesh and other tissues, and subsequent disorganisation, constitute the excrements, or manure, of the animal. The richer in nitrogen and phosphoric acid the food is, the more valuable will be the manure; so that the money value of a feeding stuff is not determinable merely by the amount of flesh which it makes, but also, and to a great extent, by the value of the manure into which it is ultimately converted.

Corn and oil-cakes are powerful fertilisers of the soil; but the three principles which constitute their manurial value——namely, nitrogen (ammonia), phosphoric acid, and potash—are purchasable at far lower prices in guano and other manures. Nevertheless, many farmers believe that the most economical way to produce good manure is to feed their stock with concentrated aliment, in order to greatly increase the value of their excreta. They consider that a pound's worth of oil-cake, or of corn, will produce at least a pound's worth of meat, and that the manure will be had for nothing, or, rather, will be the profit of the business. The richer food is in nitrogen and phosphoric acid, the more valuable will be the manure it yields. It follows, therefore, that if two kinds of feeding stuff produce equal amounts of meat, that the preference should be given to that which contains the more nitrogen and phosphoric acid. Mr. Lawes, who has thrown light upon this point, as well as upon so many others, has made careful estimates of the value of the manure pro-

duced from different foods. They are given in the following table:—

TABLE

Showing the estimated value of the manure obtained on the consumption of one ton of different articles of food; each supposed to be of good quality of its kind.

Description of Food.	Estimated Money Value of the Manure from One Ton of each Food.		
1. Decorticated cotton-seed cake	£6	10	0
2. Rape-cake	4	18	0
3. Linseed-cake	4	12	0
4. Malt-dust	4	5	0
5. Lentils	3	17	0
6. Linseed	3	13	0
7. Tares	3	13	6
8. Beans	3	13	6
9. Peas	3	2	6
10. Locust beans	1	2	6 (?)
11. Oats	1	14	6
12. Wheat	1	13	0
13. Indian corn	1	11	6
14. Malt	1	11	6
15. Barley	1	9	6
16. Clover-hay	2	5	0
17. Meadow-hay	1	10	0
18. Oat-straw	0	13	6
19. Wheat-straw	0	12	6
20. Barley-straw	0	10	6
21. Potatoes	0	7	0
22. Mangolds	0	5	0
23. Swedish turnips	0	4	3
24. Common turnips	0	4	0
25. Carrots	0	4	0

All the saline matter contained in the food is either converted into flesh, or is recoverable in the form of manure, but a portion of its nitrogen appears to be lost by respiration and perspiration. Reiset states that 100 parts of the nitrogen of food given to sheep upon which he experimented, were disposed of as follows:—

Recovered in the excreta	58·3
Recovered in the meat, tallow, and skin	13·7
Lost in respiration	28·0
	100·00

Haughton's experiments, performed upon men, gave results which proved that no portion of the nitrogen of their food was lost by perspiration or by respiration. Barral, on the contrary, asserts that nitrogen is given off from the bodies of both man and the inferior animals. Boussingault states that horses, sheep, and pigs exhale nitrogen. A cow, giving milk, on which he had experimented, lost 15 per cent. of the nitrogen of its food by perspiration. The amount of nitrogen which Reiset states that sheep exhale is exceedingly great, and it is difficult to reconcile his results with those obtained by Voit, Bischoff, Regnault, Pettenkofer, and Haughton. Of course, men and sheep are widely different animals; but still it is unlikely that all the nitrogen of the food of man should be recoverable in his egesta, whilst nearly a third of the nitrogen of the food of the sheep should be dissipated as gas. I think further experiments are necessary before this point can be regarded as settled; and it is probable that it will yet be found that all, or nearly all, of the nitrogen of the food of animals is recoverable in their egesta.

Regarding, then, an animal as a mechanism by which meat is to be "manufactured," five economic points in relation to it demand the feeder's attention: these are—the first cost of the mechanism, the expense of maintaining the mechanism in working order, the price of the raw materials intended for conversion into meat, the value of the meat, and the value of the manure. In proportion to the attention given to these points, will be the feeder's profits; but they are, to some extent, affected by the climatic, geographic, and other conditions under which the farm is placed.

PART II.

ON THE BREEDING AND BREEDS OF STOCK.

SECTION I.

THE BREEDING OF STOCK.

Cross Breeding.—For many years past feeders have zealously occupied themselves in the improvement of their stock, and the result of their labors is observable in the marked superiority of the breeds of the present day over their ancestors in the last century. The improvement of animals designed as food for man is effected by keeping them on a liberal dietary, by selecting only the best individuals for sires and dams, and by combining the excellencies of two or more varieties of a species in one breed. A species consists of a number of animals which exhibit so many points of resemblance, that they are regarded by the great majority of naturalists to be the descendants of a single pair. If we except the believers in the hypotheses relative to the origin of existing varieties of animals and plants, propounded by Lamarck, Darwin, and other naturalists of the "advanced school," there is a general belief in the immutability of species. The individuals of an existing species, say dogs, can never acquire the peculiar features of another species; nor can their descendants, if we except hybrids, ever become animals in which the characteristics of the dog tribe are irrecognisable. By various influences, such as, for example, differences in food and climate, and domestication, a species may be split into *varieties*, or *breeds*, all of which, however, retain the more important characteristics

of the primordial type. There appears to be no limit to the varieties of dogs, yet one can perceive by a glance that there is no specific difference between the huge Mont St. Bernard dog and the diminutive poodle, or between the sparse greyhound and the burly mastiff. All the varieties of our domestic fowl have been traced to a common origin—the wild Indian fowl (*Gallus bankiva*). Even Darwin admits that all the existing kinds of horses are, in all probability, the descendants of an original stock; and it is generally agreed that the scores of varieties of pigeons own a common ancestor in the rock pigeon (*Columba livia*).

As certain individuals are grouped by naturalists into species, so particular species, which in habits and general appearance resemble each other, are arranged under the head of genus. The horse, the ass, and the zebra are formed on nearly the same anatomical plan; they are therefore classed together, and designated the genus *Equus*, a term derived from the Latin word *equus*, a horse—that animal being regarded as the type, or perfect member of the group. Thus the horse, in the nomenclature of the naturalist, is termed *Equus caballus;* the ass, *Equus asinus;* and the zebra, *Equus zebra.* By a further extension of this principle of classification, very closely allied genera are united under the term of *family.*

The different varieties of the same species breed, as might be anticipated, freely together; but it frequently happens that two individuals of different species pair, and produce an animal which inherits some of the properties of each of its progenitors. These half-breeds are termed *hybrids*, or *mules*, and we have familiar examples of them in the common mule and the jennet. As a general rule, animals exhibit a disinclination to breed with other than members of their own species; and although the interference of man may overcome this natural repugnance, he can only effect the fruitful congress of individuals belonging to closely allied species, being members of the same genus. Hybrids in the genus *Equus* are very common. A cross has been produced between the he-goat and

the ewe; the camel and the dromedary have bred together; and Buffon succeeded in producing a hybrid in which three animals were represented—namely, the bison, the zebu, and the ox. On the other hand, attempts to effect a cross between animals belonging to different families have generally failed; nor is it at all probable that a cross will ever be produced between the pig and the sheep, between the horse and the cow, or, most unlikely of all, between the dog and the cat.

It is the general belief that hybrids are sterile, or, at least, that they are incapable of propagation *inter se*. This may be true with respect to the hybrids of species not very closely allied; but that there are exceptions to the rule is quite clear from Roux's experiments with hares and rabbits. This gentleman, who is, or was, the president of a French agricultural society, but who makes no profession of scientific knowledge, has succeeded, after several failures, in producing a fruitful cross between the rabbit and the hare. This hybrid has received the name of leporide (from the Latin *leporinus*, pertaining to a hare), and it is different from former crosses, in being five parts hare, and three parts rabbit. M. Roux has bred this hybrid during the last eighteen years, and has not observed the slightest appearance of decay of race manifest itself up to the present, so that, for all practical purposes, the leporide may be regarded as an addition to the distinct species of animals. The leporide fattens rapidly, and with but little expenditure of food. Sold at the age of four months, it realises, in France, a price four times greater than that commanded by a rabbit of the same age; and at a year old it weighs on an average ten pounds, and sometimes as much as sixteen pounds. It breeds at four months, continues thirty days in gestation, and yearly produces five or six litters of from five to eight young. To produce this hybrid is by no means difficult. A leveret, just old enough to dispense with the maternal nutriment, should be placed with a few doe rabbits of his own age, apart from other animals. He will soon become familiar with the does,

and when they attain the age of puberty, all the rabbits save one or two should be removed. Speedily those left with the hare will become with young, upon which they should be removed, and replaced by others. After this the hare should be kept in a hutch by himself, and a doe left with him at night only. As the hare is naturally a very shy animal, it will only breed when perfect quietness prevails. The half-bred produced in the first instance should now be put to the hare, and a cross, three parts hare, and one part rabbit, obtained. The permanent breed should then be obtained by crossing the quadroon doe leporide, if I may use the term, with the half-bred buck.

I have directed attention to the production of the leporide because I believe that the problems in relation to it, which have been solved by M. Roux, have an important bearing upon the breeding of animals of greater importance than hares and rabbits. Here we find a race of animals produced by the fusion of two species, which naturally exist in a state of mutual enmity, and which differ in many important respects. The hare and the rabbit are respectively of but little value as food, at least they are of no importance to the feeder; yet a cross between them turns out to be an excellent meat-producing animal, which may be reared with considerable profit to the feeder. It is thus clearly shown that two kinds of animals, neither of which is of great utility, may give rise to an excellent cross, if their blood, so to speak, be blended in proper proportions. A half-bred animal may be less valuable than its parents, but a quadroon may greatly excel its progenitors. The goat and sheep are so closely related that they are classed by naturalists under one head—*Capridæ*. Some kinds of sheep have hair like goats, and certain varieties of goats have fleeces that closely resemble those on the sheep. There are sheep with horns, and goats without those striking appendages. The Cape of Good Hope goat might easily be mistaken for a sheep. It would seem, judging by the results of Roux's experiments, that there is no great difficulty in the way of obtaining a cross between the sheep

and the goat. I do not mean an ordinary half-breed, but a prolific hybrid similar to the leporide. Of course, it is impossible, *a priori*, to say whether or not such a hybrid race, supposing it produceable, would be valuable; but as goats can find a subsistence on mountains where sheep would starve, it is possible that an animal, essentially a sheep, but with a streak of goat blood in it, could be profitably kept on very poor uplands. Whether a race of what we might term *caprides* be formed or not we have derived most suggestive information from M. Roux's experiments, which I hope may be turned to account in what is by far the most important field of enquiry, the judicious crossing of varieties of the same species.

It is a *quæstio vexata* whether or not the parents generally exercise different influences upon the shape and size of their offspring. Mr. Spooner supports the supposition—a very popular one—that the sire gives shape to the external organs, whilst the dam affects the internal organisation. I have considerable doubt as to the probability of this theory. The children who spring from the union of a white man with a negress possess physical and intellectual qualities which are nearly if not quite the *mean* of their parents; but the offspring of parents, both of the same race—be it Caucasian, Mongolian, or Indian—frequently conform, intellectually and corporeally, to either of their progenitors. Thus, of the children of a tall, thin, dark man, and a short, fat, fair woman, some will be like their father, and the others will resemble their mother, or, perhaps, all may "take after" either parent. Sometimes a child appears to be in every respect unlike its parents, and occasionally the likeness of an ancestor appears in a descendant, in whom no resemblance to his immediate progenitors can be detected. It is highly probable that both parents exercise, under most circumstances, a joint influence upon the qualities of their offspring, but that one of them may produce so much greater an effect that the influence of the other is not recognisable, except perhaps to a very close observer. But I doubt very much that any particular organ of the offspring is, as a rule, more liable to the

influence of the sire than of the dam, or *vice versâ;* and the breeder who believes that the sire alone is concerned in moulding the external form of the offspring, and who consequently pays no attention to this point in the dam, will often find himself out in his reckonings. In order to be certain of a satisfactory result, the dam should in every respect be equal to the sire. In practice, however, this is not always the case, for as sires are so few as compared with the number of dams, the greatest efforts have been directed towards the improvement of the former.

There is, or ought to be, a familiar maxim with breeders, that "like begets like, or the likeness of an ancestor." This is a "wise saw," of which there are many "modern instances:" the excellencies or defects of sire or dam are certain to be transmitted through several generations, though they may not appear in all. As a general rule, good animals will produce a good, and defective animals a defective, offspring, but it sometimes happens that a bull or cow, of the best blood, is decidedly inferior, whilst really good animals are occasionally the produce of parents of "low degree." If the defects or excellencies of animals were ineradicable there would be no need for the science of breeding; but by the continual selection of only the most superior animals for breeding purposes the defects of a species gradually disappear, and the good qualities are alone transmitted. As, however, animals that are used as food for man are to some extent in an abnormal condition, the points which may be excellencies in that state, would not have been such in the original condition of the animal. We find, therefore, that the improved breeds of oxen and sheep exhibit some tendency to revert to their original condition, and it is only by close attention to the diet, breeding, and general management of these animals that this tendency can be successfully resisted. Sometimes, however, an animal of even the best breed will "return to nature," or will acquire some undesirable quality; such an animal should be rejected for breeding purposes, for its defects would in all probability be transmitted to its descendants,

near or remote. A case, which admirably illustrates this point, is recorded in the *Philosophical Transactions* for 1813, and it is sufficiently interesting to be mentioned here:—

Seth Wright, who possessed a small farm on the Charles River, about sixteen miles from Boston, had a small flock, consisting of fifteen ewes and one ram. One of these ewes, in 1791, produced a singular-shaped male lamb. Wright was advised to kill his former ram and keep this new one in place of it; the consequence was, the formation of a new breed of sheep, which gradually spread over a considerable part of New England, but the introduction of the Merino has nearly destroyed them again. This new variety was called the Otter, or "Ankon" breed. They are remarkable for the shortness of their legs, and the crookedness of their forelegs, like an elbow. They are much more feeble and much smaller than the common sheep, and less able to break over low fences; and this was the reason of their being continued and propagated.

Here we have an instance of an animal propagating a defect through a great number of descendants, though it had not acquired it from its own ancestors. It is, however, probable that occasionally a male descendant of this short-legged ram possessed considerably longer organs of locomotion than the founder of his breed; and, consequently, if selected for breeding purposes might become the founder of a long-legged variety, in which, however, a couple of pairs of short-legs would occasionally present themselves. I have a notion that the higher animals are in the scale of being, the greater is their tendency to transmit their acquired good or bad habits to their posterity. Dogs are, perhaps, the most intelligent of the inferior animals, and it is well known that they transmit to their offspring their acquired as well as their natural habits. I doubt very much that those most stupid of creatures, guinea-pigs, possess this property in any sensible degree; or, indeed, that like the canine tribe, they can be readily made to acquire artificial peculiarities: but there once flourished a "learned pig," and it would be worth inquiring whether or not its descendants, like the descendants of the trained setter, and pointer, were at all benefited by the education of their ancestor. I shall

conclude this part of my subject in the words of Professor Tanner: "In all cases where the breed has been carefully preserved pure, great benefit will result from doing so. The character of a breed becomes more and more concentrated and confirmed in a pedigree animal, and this character is rendered more fully hereditary in proportion to the number of generations through which it has been transmitted. By the aid of pedigree, purity of blood may be insured, and a systematic plan adopted by which we can perpetuate distinct families, and thereby obtain a change of blood without its being a cross. It is evident that any one adopting a systematic arrangement will be able to do this more effectually than another without this aid. This is the more important when the number of families is small, as is the case with Devons and Herefords, especially the former. The individual animals from which the Devons are descended are very limited in number, and in a few hands; but, with some honourable exceptions, little attention is given to this point. The importance is rendered evident by the decreasing size of the breed, the number of barren heifers, and the increased delicacy of constitution shown in the stock of many breeders of that district who are not particular in this respect. The contrast between such herds, and those in which more care and judgment are exercised, renders the advantages of attention to pedigree very evident; for here the strength of constitution is retained, together with many of the advantages of this valuable breed."

SECTION II.

THE BREEDS OF STOCK.

THE nature of the animal determines, as I have already stated, the proportion of its food carried off in its increase; but this point is also greatly influenced by its *variety*, or

breed. Certain breeds which have for a long period been kept on bulky food, and obliged to roam in quest of it, appear to have acquired a normal tendency to *leanness.* No doubt, if they were supplied with highly nutritious food for many successive generations, these breeds might eventually exhibit as great a tendency to fatten as they now do to remain in a lean condition. As it is, the horned cattle of Kerry, Wales, and some other regions, rarely become fat, no matter how abundantly they may be supplied with fattening food. On the other hand, the Herefords, but more especially the Shorthorns, exhibit a natural disposition to obesity, and such animals alone should be stall-fed. It is noteworthy that animals which are naturally disposed to yield abundance of milk are often the best adapted for fattening; but it would appear that the continuous use of highly fattening food, and the observance of the various other conditions in the *forcing* system, diminish the activity of the lacteal secretion, and increase the tendency to fatness in the races of the bovine tribe. The Shorthorns were at one time famous for their milking capabilities, but latterly their galactophoric reputation has greatly declined. Still I am disposed to believe, that if some of those animals were placed under conditions favorable to the improvement of dairy stock, herds of Shorthorn milch cows could be obtained which would vie in their own line with the famous fat-disposed oxen of the same breed.

In sheep the tendency to early maturity and to fatten is greatly influenced by the breed. The Leicester, even when kept on inferior pasture, fattens so rapidly that in eighteen months it is fit for the butcher; whilst the Merino, though supplied with excellent herbage, must be preserved for nearly four years before it is ready for the shambles. The crossing of good herds has resulted in the development of numerous varieties, all remarkable for their aptitude to fatten and to arrive early at maturity. The Leicester—itself supposed to be a cross—has greatly improved the Lincoln, and the Hampshire and Southdown have produced an excellent cross. Of

course, each breed and cross has its admirers; indeed, the differences of opinion which prevail in relation to the relative merits of the Lincoln and the Leicester—the Southdown and the Shropshiredown—the Dorset and the Somerset—occasionally culminate into newspaper controversies of an exceedingly ascerb character. There is no doubt but that particular breeds of sheep thrive in localities and under conditions which are inimical to other varieties; but still it is equally evident that, *cæteris paribus*, one kind of sheep will store up in its increase a larger proportion of its food than another kind, and will arrive earlier at maturity. It is the knowledge of this fact which has led to the great estimation in which are held some half-dozen out of the numerous breeds and cross-breeds of that animal. In 1861 an interesting experiment was made by the Parlington Farmers' Club with the object of testing the relative merits of several varieties of sheep. The results are shown in the tables:—

TABLE I.

Description of Class of Sheep.	Live Weight of Six Wethers when Shorn, 26th February, 1862.		Weight of Mutton when Slaughtered.		Weight of Tallow.	Weight of Wool.	Weight of Pelts.	Weights gained during the time of Feeding from the 11th November, 1861, to 14th February, 1862.					
								In Live Weight.		In Mutton.		In Wool.	
	st.	lb.	st.	lb.	lb.	lb.	lb.	st.	lb.	st.	lb.	lb.	oz.
Cross from the Tees-water	85	3	53	1	106	43	85	13	7	8	6	14	5
North Sheep	83	12	53	12	96	43½	83	12	11	8	3	14	8
Lincolns	92	1	59	12	105	66	103	16	1	10	7	22	0
South Downs	71	0	47	7	97¼	28	65¾	11	13	8	0	9	5
Shropshire Downs...	85	6	53	1	103	42½	91	15	11	9	12	14	3
Leicesters	80	9	53	4	90½	44	78½	14	10	9	10	14	11
Cotswolds	76	5	47	6	79	54	90	12	6	7	11	18	0

TABLE II.

Description of Sheep.	Value of the preceding Mutton and Wool so gained.								Food consumed during time of Feeding.		Value of the Food, calculating Turnips at 6s. 8d., and Cake at £10 10s. per ton.			Value of the Mutton and Wool.			Value of Food deducted from Value of Mutton and Wool, showing real value of the different Sheep.		
	Price of the Mutton.				Price of the Wool.														
	p.lb.				p.lb.				Swd. Tnp.	Lnd. Cke.									
	d.	£	s.	d.	d.	£	s.	d.	st.	lb.	£	s.	d.	£	s.	d.	£	s.	d.
Teeswater, Cross ...	6	2	19	0	18	1	1	6	978	300	3	8	10½	4	0	6	0	11	7
North Shropshire	6	2	17	6	17½	1	1	1¾	914	300	3	6	2½	3	18	7¾	0	12	5
*Lincolnshire	5¾	3	10	5¼	18	1	13	0	936	363	3	13	0¼	5	3	5¼	1	10	5
Southdowns ..	6½	3	0	8	17	0	13	2½	684	300	2	16	7½	3	13	10½	0	17	3
Shropshire ...	6¼	3	11	10½	17½	1	0	7¾	924	300	3	6	7¾	4	12	6¼	1	5	10
Leicester ...	5¾	3	5	2	18	1	2	0	877	300	3	4	8	4	7	2	1	2	6
Cotswolds ...	6	2	14	6	18	1	7	0	926	300	3	6	8½	4	1	6	0	14	9½

These results, taken with the customary *grain of salt*, tell well for the improved Lincoln; they also clearly show the aptitude to fatten, without much loss in offal, of the Leicester;† and they commend to the lover of good mutton the Shropshire and South-Downs.

In the sixteenth volume of the Journal of the Royal Agricultural Society of England, Mr. Lawes gives some valuable information relative to the comparative fattening qualities of different breeds of sheep. The following table, on this author's authority, shows the average food consumed in producing 100 lbs. increase in live weight:—

* Improved by Leicester blood.

† The object of the first breeders of the Leicester was to produce a sheep which would yield a great carcass, and small offal weight. So far as the results of these experiments go, I think the idea of the founder of this breed has been realised.

Breed.	Oil Cake.	Clover.	Swedes.
Sussex	297¼	285½	3·835¾
Hampshire	291½	261¼	3·966¾
Cross-bred Wethers ...	264½	251¾	3·725¼
Do. Ewes	263½	250¼	3·671
Leicesters	263¾	251¼	3·761
Cotswolds	253½	216¾	3·557½

Some breeds are profitably kept in certain localities, where other kinds would not pay so well: for example, the Devons, according to Mr. Smith, are better adapted than larger breeds for "converting the produce of cold and hilly pastures into meat." It is remarkable that nearly all the best existing breeds of oxen and sheep are crosses. Major Rudd states that the dam of Hubback, the famous founder of pure improved Shorthorns, owed her propensity to fatten to an admixture of Kyloe blood, and also that the sire of Hubback had a stain of Alderney, or Normandy blood. Although the Rudd account of the ancestry of Hubback is not accepted by all the historians of this splendid breed of cattle, there is no doubt but that the breed owes its origin as much to judicious crossing as to careful selection of sires and dams. It must not, however, be imagined that there are no good pure races of stock. There is a perfectly pure, but now scarce, tribe of Kerry oxen, admirably adapted to poor uplands. The excellent Southdown sheep, though in every respect immensely superior to their ancestors in the last century, have not attained to their present superior state by crossing. The high value placed by breeders upon good sires and dams in the approved breeds of stock is shown by the large sums which they frequently realise at sales, or when the former are let out for service. Bakewell received in one season for the use of a ram 400 guineas each from two breeders, and they did not retain the animal during the whole season. Several hundred guineas have lately been more than once paid for a celebrated tup. Colonel Towneley's Shorthorn bull, Master Butterfly, was, not long since, disposed of to an

Australian buyer for £1,260. At the sale of Mr. Bates's stock in 1850, a stock of Shorthorns, including calves, brought on the average £116 5s. per head. At the Earl Ducie's sale in 1852, a three year old cow — Duchess — realised 700 guineas.

The color of an animal is, to some extent, a criterion of the purity of its breed. Roan is a favourite hue with the breeders of Shorthorns. There have been celebrated sires and dams of that breed perfectly white; but that color, or rather absence of color, is now somewhat unpopular, partly from the idea that it is a sign of weakness of constitution—a notion for which there appears to me to be no foundation in fact. The slightest spot of black, or even a very dark shade, is regarded to be a blemish of the most serious kind when observed on the pelt of a Shorthorn. The Herefords are partly white, partly red; the Devon possesses in general a deep red hue; the Suffolks are usually of a dun or faint reddish tint; the Ayrshires are commonly spotted white and red; and the Kerrys are seen in every shade between a jet black and a deep red. Uniformity in color would be most desirable in the case of each variety, and this object could easily be attained if breeders devoted some attention to it.

The Form of Animals.—The functions of an animal are arranged by Bichat, an eminent physiologist, into two classes —those relating to its nutrition, and those exhibited by its muscular and mental systems. The first class of functions comprise the *vegetative*, or organic life of the animal, and the second class constitute its *relative* life.. Adopting this arrangement, we may say, then, that those animals in which the vegetative life is far more energetic than the relative life are best suited for the purposes of the feeder. In tigers, wolves, and dogs the relative life predominates over the vegetative; the muscles are almost constantly in a high degree of tension, and the processes of nutrition are in constant requisition to supply the waste of muscle. On the

other hand, in oxen, sheep, and pigs, at least when in a state of domesticity, the muscles are not highly developed; they do not largely tax the vegetative processes, and, consequently, the substances elaborated under the influence of the vegetative life rapidly increase. The form of an animal is therefore mainly determined by the activity of its relative life. In a greyhound, the nervous power of which is highly developed, the muscles are large and well-knit, the stomach, intended for the reception of concentrated nutriment only, is small, and the lungs are exceedingly capacious. In such an animal the arrangements for the rapid expenditure of nervous power must be perfect. It is not merely necessary that its muscles should be large and powerful, its lungs must also admit of deep inspirations of oxygen, whereby the motive power wielded by these muscles may be rapidly generated. Now, an animal exactly opposite in organisation to the greyhound would, according to theory, be just the kind to select for the production of meat. The greyhound and the horse expend all their food in the production of motive power; the ox and the sheep, being endowed with but a feeble muscular organisation, use a smaller proportion of their food for carrying on the functions of their relative life, consequently, the weight of their bodies is augmented by the surplus nutriment. It is clear, then, that an animal of a lymphatic temperament, an indolent disposition, a low degree of nervous power, and a tendency to rapid growth, is the *beau ideal* of a "meat-manufacturing machine." Now, as the larger the lungs of an animal are, the greater is its capacity for "burning," or consuming its tissues, one might suppose that small lungs would be a *desideratum* in an ox, or other animal destined for the shambles. This appears to be Liebig's opinion, for in one of his books he states that "a narrow chest (small lungs) is considered by experienced agriculturists a sure sign, in pigs, for example, of easy fattening; and the same remark applies to cows, in reference to the produce of milk—that is, of butter." On this subject Professor Tanner makes the following remarks,

in his excellent Essay on Breeding and Rearing Cattle:*—"In our high-bred animals we find a small liver and a small lung, accompanied with a gentle and peaceful disposition. Now, these conditions, which are so desirable for producing fat, are equally favorable for yielding butter. The diminished organs economise the consumption of the carbonaceous matters in the blood, hence, more remains for conversion into fat, but equally prepared for yielding cream, if the tendency of the animal is equally favorable to the same." One would imagine, from the foregoing passage, that Mr. Tanner and Baron Liebig coincided in believing small lungs necessary to rapid fattening; but in another part of his essay, Tanner thus describes one of the points indicative of a tendency to fatten early:—"The chest should he bold and prominent, wide and deep, furnished with a deep but not coarse dewlap." On comparing the two passages which I have quoted from Tanner's essay, a contradiction is apparent. Mr. Bowly, Major Rudd, and other eminent breeders and feeders, appear to regard a capacious chest as the best sign of a fattening property which an animal could show. Lawes and Gilbert have recorded the weights of the viscera of a number of animals which, though supplied with equal quantities of the same kind of food, attained to different degrees of fatness. On carefully scrutinising these records, I failed to perceive any constant relation between the weight of their lungs and their tendency to fatten rapidly. Some animals with large lungs converted a larger proportion of their food into meat than others with smaller respiratory organs, and *vice versâ*. In a state of nature, there is no doubt but that the lungs of the ox and of the sheep are moderately large; and it is evident that in their case, as well as in that of man, over-feeding and confinement tend to diminish their muscular energy, and, of course, to decrease the capacity of the lungs. That such a practice does not tend to the improve-

* "Transactions of the Highland and Agricultural Society of Scotland," for July, 1860.

ment of the health of an animal is perfectly evident, but then the perfect ox of nature is very different from the perfect ox of man. The latter is a wide departure from the original type of its species: any marked development of its nervous system is undesirable; and it is valuable in proportion as its purely vegetative functions are most strongly manifested. A young bullock, therefore, of this kind would, no doubt, be the most economical kind to rear, provided that it was perfectly healthy, and capable of assimilating the liberal amount of food supplied to it. But it rarely happens that a young animal with a weakly chest turns out other than a scrofulous or otherwise diseased adult. On the whole, then, I am disposed to believe that whilst naturally small-lunged species may be more prone to fatten than large-chested ones, it is not the case that small-chested individuals fatten more rapidly than larger lunged individuals of the same kind.

The conditions under which oxen, sheep, and pigs have been so long maintained in civilised countries, must have diminished the capacity of their chests in relation to other parts of their bodies; and it may be fairly doubted if any good could result by reducing to still smaller dimensions those most important organs. Probably the lungs and hearts of the improved breeds of stock are already too small, and that it is only the individuals which are least affected in this respect that answer to Mr. Bowly's description of a fat-disposed beast. Whether or not small lungs are desirable in a bullock or milch cow, it is certain that a ram or a bull should be possessed of a capacious chest, for otherwise he will have but little vigour, and will be likely to produce a weakly offspring. A sire should be a perfectly developed animal in every respect—sound lungs and heart, and not over fat. It is sufficient that it belongs to a good fattening breed; but to produce offspring with a tendency to fatness and early maturity, it is not necessary that the sire should himself be obese. It is to be regretted that so many sires of the Shorthorns and other improved varieties should be used for breeding purposes,

when their hearts and lungs have become, by over-feeding the animals, unfitted for the proper discharge of their function. The progeny of such sires must *naturally* inherit the *acquired taint* of their diseased progenitors, and prove weakly and unhealthy animals.

With respect to the general outline structure of a bull, he should have a small, well-set head, rounded ribs, straight legs, small bones, and sound internal organs. The following are considered to be the best points in a Shorthorn bull :—A short and moderately small head, with tapering muzzle and broad forehead, furnished with short, white, curved, graceful looking horns ; bright, yet mild, large eyes, placed in prominent orbits ; dilated nostrils, and flesh-colored nose, and long, thin ears. The neck should be broad, deep, and muscular, sloping in a graceful line from the shoulder to the head. The chest should be wide, deep, projecting, but level in front. The shoulders should be oblique, the blades well set in towards the ribs. The forelegs should be stout, muscular above the knee, and slender below it ; the hind legs should be slender to the hock, and from thence increase in thickness to the buttocks, which should be well developed. The carcass should be well rounded at each side, but level on the back and on the belly. There should be no hollows between the shoulder and the ribs, the line from the highest part of the shoulder to the insertion of the tail should be a perfect level. The flank should be full, the loins broad, and the tail finely formed and only partially covered with hair. The skin is a prime point : it must be covered with hair of a roan, or other *fashionable* color, and communicate to the hand of the experienced feeler, a peculiar sensation, which it is impossible to describe. With regard to this point, I cannot do better than quote the words of an experienced "handler" :—

"A nice or good judge of cattle or sheep, with a slight touch of the fingers upon the fatting points of the animal—viz., the hips, rump, ribs, flanks, breast, twist, shoulder score, &c. will know immediately whether it will make fat or not, and in

which part it will be the fattest. I have often wished to convey in language that idea or sensation we acquire by the touch or feel of our fingers, which enables us to form a judgment when we are handling an animal intended to be fatted, but I have as often found myself unequal to that wish. It is very easy to know where an animal is fattest which is already made fat, because we can evidently feel a substance or quantity of fat—all those parts which are denominated the fatting points; but the difficulty is to explain how we know or distinguish animals, in a lean state, which will make fat and which will not—or rather, which will make fat in such points or parts, and not in others—which a person of judgment (*in practice*) can tell, as it were, instantaneously. I say *in practice*, because I believe that the best judges *out of practice* are not able to judge with precision—at least, I am not. We say this beast *touches* nicely upon its ribs, hips, &c., &c., because we find a mellow, pleasant feel on those parts; but we do not say soft, because there are some of this same sort of animals which have a soft, loose handle, of which we do not approve, because, though soft and loose, have not the mellow feel above mentioned. For though they both handle soft and loose, yet we know that the one will make fat and the other will not; and in this lies the difficulty of the explanation. We clearly find a particular kindliness or pleasantness in the feel of the one much superior to the other, by which we immediately conclude that this will make fat, and the other not so fat; and in this a person of judgment, and *in practice*, is very seldom mistaken."

In many respects the good points in a Shorthorn cow resemble those in the male of that breed, but in others there is considerable difference. As I have described in prose the excellencies which a bull should possess, I will now give a poetical summary of the good points of a cow of that breed, extracted from the *Journal of Agriculture*, and composed evidently by an excellent breeder and poet, Mr. Carr:—

The following features constitute, I trow,
The beau ideal of a short-horn cow :—
Frame massive, round, deep-barrell'd, and straight-back'd ;
Hind quarters level, lengthy, and well pack'd ;
Thighs wide, flesh'd inwards, plumb almost to hock ;
Twist deep, conjoining thighs in one square block ;
Loin broad and flat, thick flesh'd, and free from dip ;
Back ribs "well home," arch'd even with the hip ;
Hips flush with back, soft-cushion'd, not too wide ;
Flanks full and deep, well forward on the side ;
Fore ribs well-flesh'd, and rounded like a drum ;
Fore flanks that even with the elbow come ;
Crop "barrell'd" flush with shoulders and with side ;
Girth large and round—not deep alone, but wide ;
Shoulders sloped back, thick cover'd wide at chine ;
Points snug, well-flesh'd, to dew-lap tapering fine ;
Neck vein fill'd up to well-clothed shoulder-point ;
Arm full above, turn'd in at elbow-joint ;
Legs short and straight, fine boned 'neath hock and knee ;
Belly cylindrical, from drooping free ;
Chest wide between the legs, with downward sweep ;
Brisket round, massive, prominent, and deep ;
Neck fine at head, fast thickening towards its base ;
Head small, scope wide, fine muzzle and dish'd face ;
Eyes prominent and bright, yet soft and mild ;
Horns waxy, clear, of medium size, unfiled ;
Tail fine, neat hung, rectangular with back ;
Hide soft, substantial, yielding, but not slack ;
Hair furry, fine, thick set, of colour smart ;
Udder well forward, with teats wide apart.
These points proportion'd well delight the eye
Of grazier, dairyman, and passer-by ;
And these to more fastidious minds convey
Appearance stylish, feminine, and gay.

Breeds of the Ox.—The Shorthorned cattle are now generally regarded as the most valuable breed in these countries. They are the descendants of a short-horned breed of cattle which existed for centuries in the north-east of England. They were not held in much estimation, their flesh being coarse ; but the cows of this breed yielded abundance of milk. In the eighteenth century

this breed, it is said, was greatly improved by a large infusion of blood from Dutch Shorthorns: but it is very doubtful that any such event took place, for during that period the importation of cattle into Great Britain was prohibited by very stringent laws. The present race of Shorthorns owe most of their valuable qualities to the brothers, Charles and Robert Colling, of the county of Durham. The former was the more successful breeder, and established the celebrated breed of Ketton Shorthorns. His whole process appears to have consisted in the careful selection of parents, and in "close" breeding. He must, however, have been an admirable judge of the good points of the ox, for beginning with animals not worth more on an average than £10 each, he produced in less than a quarter of a century a stock worth on the average £150 each. The most famous bull of Charles Colling's was Comet. The sale of this animal realised the handsome sum of 1,000 guineas. The bull Hubback is said by many writers to have been the great improver of Shorthorn blood. He was bought by Robert Colling for the trifling sum of £8; but although this animal was kept by both Collings for three years, there is good reason to believe that they made but little use of him. It would appear, indeed, that to the cows first used by the Collings—Lady Maynard, and young Strawberry—many of the good qualities of this breed are traceable. Shorthorns are now to be found in almost every part of the United Kingdom, capable of maintaining heavy stock. In Ireland the breed has been greatly improved, and it is gradually supplanting most of the other varieties.

Shorthorn males have a short, wide head, covered very often with short curly hair; the muzzle is taper; the ear rather long and narrow; the eye large, and bright, and mild. The shape is symmetrical, the carcass deep, the back level, ribs spreading out widely, and the limbs fine. The color is a mixture of red and white, sometimes a rich roan. The females are not so large in the head, which tapers more, and the neck is much thinner.

The DEVONS are not so large as the Shorthorns. Their shape is symmetrical; fine head, horns of medium size, often tapering gracefully; rich red or orange red color; forequarters rather oblique. The meat of this breed is much esteemed: they yield excellent milk, but in rather limited quantity; and the bullocks answer the plough much better than many other kinds do. These animals arrive early at maturity.

The HEREFORDS are a rather small-boned breed; their horns are medium sized, straight or slightly curved upwards; their color is dark red; neat shoulders, thin thighs, and wide sirloin. They fatten well, but are not generally kept on dairy farms. In many respects they resemble the Devons.

The AYRSHIRES have a tapering head, fine neck, and large, bony, but not coarse carcass; flat ribs; short and rather ugly horns; their skin is soft, and covered with hair, which is usually red and white in spots. The Ayrshire cows are invaluable for dairy purposes.

The POLLED ANGUS, POLLED ABERDEENS, and POLLED GALLOWAYS are very large cattle, with big heads, unfurnished with horns. Their color is in general a decided black, but occasionally it exhibits a mixture of black and white. Their flesh is in general not of the best quality, but some of their crosses with Shorthorns yield excellent meat, and at an early age, too.

The KYLOES are a breed peculiar to the Highlands of Scotland. They are rather rough, but very picturesque animals, covered with long, shaggy hair. Their horns are rather long, and curve upwards. Their hair is differently colored—red, yellow, dun, and black, the latter being the prevailing hue. No variety of the ox yields a sweeter meat than the Kyloes, and other mountain breeds of these countries. The animals, however, arrive slowly to maturity, and in this respect there is great room for improvement. These mountain-bred animals are now transferred in large numbers to lowland tillage farms, where the fattening process

is more expeditiously performed. There are excellent crosses between Shorthorn bulls and Highland cows.

LONGHORNED CATTLE are rapidly advancing towards extinction. At one time they were the chief breed kept by most farmers. In general they may be regarded as an inferior variety, being slow feeders, and producing rather coarse beef. They are, however, capable of great improvement, as instanced in the case of Bakewell's celebrated Longhorn herds.

The KERRYS are a diminutive breed, peculiar to Ireland. They have small heads, fine necks, fine horns of medium length, and curved upwards near their summits. They have a soft skin; the hair is generally black, interspersed with a few white streaks; sometimes their color is red, and occasionally brown. They are a very hardy race, being indigenous to mountains. Their flesh is very good, more especially if the animals have been kept on fattening food. The Kerrys are good milch cows.

The ALDERNEYS are a small race of oxen with deer-like faces. They exhibit various shades of red, white, brown, and roan. No cows yield better milk, or larger quantities of that fluid.

Sheep.—The different breeds of sheep are classified under three heads—viz., *Long-woolled*, *Short-woolled*, and *Middle-woolled.*

The LEICESTER is, perhaps, the most celebrated breed of sheep reared in these countries. It was immensely improved by Bakewell about a century ago, and the breed is often termed the Dishley, after the name of Bakewell's residence. This sheep has a wide, clean head, broad forehead, fine eyes, long, thin ears, thick neck, round body, deep chest, straight, broad back, high ribs, and muscular thighs. The wool is long, very thick, and fine. At from fifteen to eighteen months old, the Leicester weighs from 25 to 30 lbs. per quarter; but a fat animal often weighs from 38 to 40 lbs. per quarter. The fleece weighs from 6 to 8 lbs. This breed is well adapted for Ireland. It is reared on very poor land: but in order to

maintain its good quality, this sheep requires abundance of food, and also good shelter during the winter.

The LINCOLN is distinguished for its large bones and strong muscles. Originally a gaunt and ugly animal, it has of late years been much improved. Indeed, the prices lately realised by Lincoln sheep are extremely high. The Lincoln has a long, white face, long body, and thick legs. The wool is long, thick, and moderately fine. The flesh of the Lincoln is lean, owing to its great muscular development. At fifteen months old it yields about 30 lbs. weight per quarter. It is said that a Lincoln wether has attained the weight of 304½ lbs. The average weight of the wool of a hogget is 9½ lbs.

The COTSWOLD breed arose in the Cotswold hills, in Gloucestershire. In this variety the skeleton is large, the chest capacious, the back broad and straight, and the ribs well arched. It has good quarters, and a finely-arched neck. It is distinguished by a large tuft of wool—"fore-top," on the forehead. It fattens early, and produces about 25 lbs. per quarter when fifteen months old, and 40 lbs. when two years old. The wool is rather coarse; its yield is about 8 lbs.

The CHEVIOT has a long body, long face, long legs, and long ears. The chest projects slightly, and is rather narrow. The forehead is bare of wool; the legs and face are white, sometimes approaching to a dun shade. Weight from 70 to 80 lbs.; weight of fleece, from 3 to 4 lbs. The wool is of excellent quality, and is used largely in the manufacture of tweeds. The Cheviot is a mountain sheep, and, as might be expected, its flesh is well flavored. There are several crosses of the Cheviot with the Leicester, the Southdown, and the Shropshire.

The SOUTHDOWN is generally regarded as the best breed for wool reared in these countries. It is indigenous to the chalk hills of Kent, Sussex, Hampshire, and Dorsetshire. It has a small head; its back is broad and straight; the ribs spring out at nearly right angles from the vertebræ. It is rather light in the fore-quarters, and full in the hind quarters.

Its chest is pretty deep; its face and legs are grey or brown. The wool of the Southdown is short, and extremely fine; the fleece weighs about 3 lbs. This sheep arrives early at maturity. It weighs at 15 months old about 80 lbs. The flesh is very well flavored.

THE SHROPSHIRE is said to combine in itself the good qualities of the Southdown, the Cotswold, and the Leicester. It resembles the Southdown more than any other breed, having the same grey, or brownish grey hue, and a similar shape. It is, however, larger than the Southdown, and yields a larger quantity of wool. This breed is becoming a great favorite in both England and Ireland.

The BLACK-FACED sheep is peculiar to Scotland. It is equipped with horns, has a bold long face, and possesses a tuft of wool on its forehead; its limbs are strong, and its body is somewhat long. The wool of this breed is very coarse, the fleece weighs about 3½ lbs. The average weight of this sheep is 75 lbs., the quality of the mutton is excellent, but it is long before it becomes matured. There are several other breeds of the sheep, but they are of far less importance than those which I have described.

Breeds of the Pig.—There are several breeds of this useful animal, of which those known as BERKSHIRE and YORKSHIRE appear to be the greatest favorites. The Berkshire is black or dusky brown, very rarely reddish brown. It has a very small head. Its sides are extremely deep, and its legs very short. There are several sub-varieties of the Yorkshire. This breed is white, has a compact body, and very broad sides. The head is very small, somewhat like that of the Berkshire. Both Berkshire and Yorkshire pigs attain to the enormous weight of 1,000 lbs. The old Irish "racer" pig is the least profitable kind to keep, but fortunately it is, as a pure breed, nearly extinct.

Breeds of the Horse.—There are a great many breeds of horses. The Shetland pony is so small, that many specimens are no larger than a Newfoundland dog; on the other hand, Clydesdale horses sometimes attain to almost elephantine pro-

portions. There is a wide difference between the bull-like Suffolk Punch and the greyhound-like *racer.* The English and Irish racer is said to owe its origin to a cross between the old English light-legged breed and the Arabian. The most valuable kind of carriage horse is the joint product of the draught-horse and the racer. The dray-horse of these countries has a large share of Flemish blood in him. The best horses for agricultural purposes are unquestionably the CLYDESDALE and the SUFFOLK PUNCH. The latter is perhaps to be preferred in most instances, especially on light lands. Very light and feeble horses are the most expensive variety on almost any kind of farm; for whilst they consume nearly as much food as the most powerful animals, and are therefore nearly as costly, they are incapable of effectively performing their work. A large proportion of the farm horses used by the small farmers of Ireland are totally unsuited for tillage purposes. On the other hand, there is no need to employ horses equal in size to the ponderous creatures that draw brewers' carts. Moderate sized horses, with well rounded, compact bodies, and muscular but not too heavy limbs, are the kind best adapted for farm purposes. In Ireland, where there are not fewer than 600,000 horses, a considerable infusion of blood from Clydesdales and Suffolk Punches is much required.

Hunters and Racers.—There is a strong tendency in the human mind to look with a regretful feeling to the past, and to compare it to the disadvantage of the present. It is a general belief with most people that the old time was the best time; that the seasons were more genial formerly; that provisions were cheaper and more abundant; that men were taller, and stouter, and healthier; that, in a word, everything was better in the days of yore than it is now, and that degeneracy and effeteness are the prevailing characteristics of our age. Philosophers, statists, and political economists tell us that all this regret for the "good old time" is mis-spent sympathy; for that we are in every respect superior—in physique, health, morals, and wealth—to our ancestors. On

the whole, I rather incline myself to this comfortable philosophy; but we must admit that we have not progressed in all things since the times of our fathers.

In a work entitled "A Comparative View of the Form and Character of the English Racer and Saddle Horse during the Last and Present Centuries," published by Hookham, of Old Bond Street, London, it is proved very clearly that the English race-horse has sadly degenerated. The author very properly traces the cause of its decay to the avarice of the turfites: they look upon the noble animal as a mere gambling machine; and they sacrifice all its other qualities to the excessive development of that one which is likely to put money in their pockets. Formerly, gentlemen kept horses for their own sakes—for their admiration and enjoyment of one of the most beautiful, docile, and useful of animals. They were incessant in their efforts to develop into perfection all the really valuable points in the animal; and the result was, that the English and Irish racer of the last century was unmatched for strength, speed, and endurance. Models of this splendid race of horses are seldom to be found at the present time; but there are, perhaps, sporting men living who saw them in the celebrated Mambrino, Sweet Briar, and Sweet William. Those horses possessed compact bodies, capacious lungs, strong loins, large joints, and enormous masses of muscular tissue on the shoulder-blades and arms. They were good weight-carrying hunters as well as racers, and they could carry eight stones over a six miles heat, or twelve stones over a four miles one. The Irish horses, at least, were capable of safely carrying thirteen stones over what would now be considered a very ugly ditch, and could get over a long steeplechase in a style which would astonish the owners of the modern "weeds." Since the distance to be traversed by competing horses has been reduced from the old-fashioned three heats of four miles each to a single run of a mile or two, and also since the weight imposed upon the animals has been reduced to six or seven stones, from ten to twelve, the anatomical

structure of the race-horse has undergone a remarkable and serious alteration. The back has become very long, the sides flat, the loins weak, the limbs long and very thin; and this alteration in structure has been attended by weakness of constitution and a remarkable tendency to disease. The modern horse has attained to a remarkable degree of rapidity of locomotion, but it has been at the expense of its vigor, endurance, and health; it can run with great velocity for a short distance, but in a four-mile heat, and mounted by a man of average weight, a mediocre horse of the style of the middle of the last century would come to the post long before the winner of the last St. Leger.

The decay of the breed of horses in this country is a serious matter, and the attention of all who are interested in the preservation of this animal should be earnestly and promptly directed towards discovering the means of regeneration. My remarks are directed towards racers and hunters. The quality of speed which they possess has been developed to an extent which is incompatible with the development of equally essential properties. Encouragement should be given to the production of weight-carrying hunters; steeple-chasing should be restored to its old state, when only a powerful horse had a chance of success. The quality of speed should be promoted in the animal up to a certain point; but when the development of this attribute begins to cause a loss of strength and endurance, it is high time to check it. There are a few horses at present which are strong and moderately fast: why should not steeple-chasing be of the kind which would call this style of animal into competition? Only a "weed" can now enter with any probability of success at a race of this kind; and when he has won it, of what use is he as a good hunter? What we want are good, stout, healthy horses, capable of carrying, in good style, twelve stones weight over a rough country; and the object of steeple-chasing should be the production of such a race of horses.

PART III.

ON THE MANAGEMENT OF LIVE STOCK.

SECTION I.

THE OX.

Breeding Cows.—The period of gestation in the cow is about nine months. The earliest time at which it is at all safe to breed from these animals is when they are one year and eight months old. Shorthorns breed early, whilst the mountain varieties are seldom in calf before they are three years old. The practice of very early breeding, though approved of by some extensive rearers of stock, is not to be commended for sound physiological reasons. Cows calve at all times of the year; but the most favorable time is near the end of winter, or in early spring. The cows should at this time be in fair condition—neither too fat nor too lean. Parturition should take place in a roomy, covered place, provided with abundance of clean litter. If such a place be not available, a nice paddock close to the house must answer. After having given birth to the calf, the cow should receive an oatmeal drink, or some warm and nutritious mash, and afterwards be liberally fed. The cow is usually allowed to run dry four or five weeks before calving: this period should not be curtailed; on the contrary, it would be better to extend it to six weeks, so as not to allow her condition to become too poor.

The Wintering of Young Stock.—There are certain localities wherein the rearing of young stock is one of the easiest tasks which devolve upon the farmer. Well-drained and shady fields,

yielding abundance of sound herbage, and through which streams of *pure* water unceasingly flow, are just the proper *locale* for economically feeding young animals. But there are districts in which those favorable conditions do not exist; yet they are not better adapted to other uses. It is only the feeders of young stock in wet, moory, sandy, or undrained, heavy soils who really have cause for anxiety and incessant watchfulness. In rearing a calf the great object is to cause a rapid and uninterrupted increase in the weight of its body. At first the food of the animal should be furnished solely from the maternal founts; but at an early stage of its existence—about the third or fourth week—other food may wholly, or in part, be substituted for the natural aliment. It is important that no great interval should elapse between the hours of feeding. The digestive apparatus of the young animal is small, and its powers of assimilation are very energetic. The food with which it is supplied should, therefore, be given in moderate quantities, and very frequently. This is, in fact, what takes place when the calf is allowed free access to its dam; for the instant it feels a desire for aliment, the supply is at once available. Of course, there may be objections to this plan on the score of economy; but as a general rule, too much liberality cannot be exercised in feeding growing animals; and there is nothing more certain than that the calf which is illiberally fed will never be developed into a valuable, matured animal. When carefully tended from their birth, comfortably housed in winter, and abundantly supplied with nutritious food, it is sometimes wonderful the rapid progress which young stock make. Mr. Wright mentions a remarkable case of early maturity, which occurred in his own herd. A young steer, one year old, exhibited all the development of an animal twice its age. This bullock had been suckled for three months, whereby it had not only kept its calf-flesh, but gained and retained a step in advance. Its weight when only a year old was no less than 50 stones; and as the price of beef at the time was 8s. 9d. per stone, live weight, the carcass of the animal was worth £21 17s. 6d. Mr.

Wright offers this fact as a suggestive one to "those farmers who think of bringing up their calves on old milk, or who would otherwise stint their growth."

Supposing, then, that we have young stock which had been liberally treated when in their "baby" state, how are we to most economically maintain them throughout the winter? In the first place, they should be kept in warm sheds, and well sheltered from both rain and wind. Some authorities contend that exercise is necessary to young stock, and deny that a proper development of the muscles (lean flesh) can take place if they are cooped up like fattening turkeys during the winter. There is some truth in this opinion; and if the animals be designed for breeding or dairy purposes, their freedom of motion should only be partially restrained. On the other hand, if they be intended for an early introduction to the shambles, the less exercise they get the greater will be the profit on their keep. I have known cases where animals were closely housed for seven months, and yet their health did not appear to suffer in the slightest degree. In fact, so predominant are the vegetative functions of the ruminants over their nervous attributes, that the only essential conditions of their existence are adequate supplies of good air and food. That the health of these animals does occasionally suffer when the motions of their bodies are reduced to a *minimum* is quite true; but in most of these instances the real cause is, not the want of exercise, but the want of pure air. The greatest care should, therefore, be taken in the ventilation of the places where stock, whether old or young, are kept; and no economy of space or heat will compensate for the want of wholesome air. Under the fallacious idea that exposure to cold renders young stock hardy, many farmers turn them out to eat straw in the open fields in frosty weather. Treatment of this kind, instead of being productive of good, almost invariably lays the foundation of disease, which will manifest itself at some stage of the animal's growth. There are a few favored localities, such as those to which I have already alluded, where yearlings may be

occasionally allowed a turn through the fields in winter; but on cold clays, wet moors, and sandy soils the young stock should never be permitted to leave their sheds or courts from the time they are housed till late in the spring.

Young stock are best fed on good meadow hay and turnips, with a moderate supplement of oil-cake; this, however, is expensive feeding in many farms, and a little filling-in may be done with cheaper or more easily obtainable stuffs. A mixture of cut chaff, with pulped mangels, is a good substitute for the more costly hay; and particularly in the case of animals intended for breeding or for the dairy. The roots should be pulped, and allowed to remain until, owing to a slight fermentation, they become warm. This change takes place in from twenty-four hours to sixty hours, according to the temperature; but the fermentation should not be carried farther than the earliest stage. The heated pulp should then be thoroughly mixed with the chaff, and the compound, after an hour or two, will be ready for use. A little chopped hay—no matter if inferior or slightly mildewed—may be substituted for the chaff, and turnips employed instead of the mangels, but the latter are the more desirable roots.

Until lately, the use of oil-cake was confined to fattening animals, but latterly it is freely given to calves, even when they are only a month old; and there is no doubt but that it is a suitable and economical food for store stock. It is, however, sometimes given in excess: from half a pound to two and a half pounds daily will be sufficient for animals under one year; and this addition to their food will be found to exercise a beneficial influence on them when they are placed in stalls for finishing. The experience of several eminent breeders has proved that fattening beasts, which had in their youth a supply of oil-cake, or its equivalent, invariably store up a larger portion of their food than those which had been reared on hay and roots only.

Mr. George Stodart, of Cultercullen, an Aberdeenshire farmer, describes, in the *Irish Farmer's Gazette*, his method of rearing calves:—

I occupy (says Mr. Stodart) a farm of 380 acres. I usually rear twenty-four calves yearly, and buy in sixteen one-year-olds. I generally breed from cross cows (the same as mentioned above), served by a pure Shorthorn bull. When the calves are dropped I put two calves to suck one cow for six months. In autumn, spring calves are put into the house upon turnips and straw, with about 1 lb. of oil-cake per day to each, until they are put out to grass in spring following, at which time they are one year old. Then, of course, they have grass in summer, and at the approach of winter they are again housed upon turnips and straw, which bring them to be two years old in spring. Now they are sent out to the best grass, and again brought into the house at the beginning of September, and fed on turnips and straw until the end of November or middle of December, when they usually fetch from £25 to £32 a-head. This year (1864), however, they will average £32 a-head. Before selling I give each 3½ lbs. of oil-cake per day for six weeks, and during this time they have swede turnips; at other times yellow. We give as much turnips at all times as they can eat.

Mr. Bowick, in his excellent paper on the rearing of calves, published in the Journal of the Royal Agricultural Society, gives the following information on this subject:—

We consider it desirable to allow the calf to remain with its dam for the first three or four days after calving.

Not much trouble is generally experienced in getting it to take to the pail. We find it better to miss the evening's meal, and next morning a very little attention induces the majority of them to partake of what is set before them. At most the guidance of the fingers may be wanted for the first meal or two.

As regards the quantity of milk which is needful to keep a moderately bred Shorthorn calf in a thriving condition, we have found the following allowance to come pretty near the mark, although the appetite of calves varies, both in individuals and at different times with the same animal:—

1st week with the dam; or 4 quarts per day, at two meals.

2nd to 4th week, 5 to 6 quarts per day, at two meals.

4th to 6th week, 6 to 7 quarts per day, at two meals.

And the quantity need not, during the ensuing six weeks (after which it is weaned), exceed a couple of gallons per day. This implies that the calf is fed upon new milk only, and that no other feeding liquids are employed. But, in addition to the above, the calf will, towards the fourth week, begin to eat a little green hay; and in a week or two later, some sliced roots, or meal, or finely crushed cake, mixed with hay-chaff; and, if really good, creditable beasts are wanted—such as will realise £25 a-head from the

butcher when turned two and a half years old—a little cake or meal in their early days will be found a desirable investment. In fact, we doubt not but 1 lb. of cake per day to the calf will make as much flesh as triple the quantity of cake at any period of after life. As regards meal, if that is given with the chaff, we prefer oatmeal, or barley-meal, or wheaten flour, but not the meal of beans or pease. Others may see it differently, but we believe beans to be too heating for any class of young stock. For roots, the best we know of is the carrot, grated and mixed with the chaff, or sliced thin with a knife and given alone. It is also, of all roots, the one which we find them most fond of, and which they will most readily take to. As soon as they can eat them freely, an immediate reduction in the supply of milk may be made.

In most articles it holds good in the end that "the best is the cheapest." So with the rearing of calves; the best class of food, or that above referred to, is found to give the greatest ultimate satisfaction. But practically the question often is, how to rear good calves with comparatively little new milk, a condition which circumstances often render almost imperative; for where dairy produce, in any other form, is the chief object, the calves stand in a secondary position, and are treated accordingly. But let us ask whether you cannot rear good stock under such circumstances also? We believe that this may be, and often is done. We manage to turn out from twenty-five to thirty calves annually—such as will pass muster anywhere—and never use at any one time more than six gallons of new milk daily. For this purpose, as well as to obtain a regular supply of milk for other purposes, the calves are allowed to come at different periods, extending from October to May. Hence the calf-house has generally a succession of occupants throughout the season; and as one lot are ready to be removed, and placed loose in a small hovel, with yard attached, others fill their places. We begin with new milk from the pail, which is continued for a fortnight after leaving the cow. Then skim-milk —boiled, and allowed to cool to the natural warmth—is substituted to the extent of one-third of the allowance. In another week the new milk is reduced to half, and at the same time, not before, boiled linseed is added to the mess.* As soon as they take freely to this food, the new milk may be replaced with that from the dairy, and the calf is encouraged to indulge in a few sliced carrots and the other dry foods named.

Mr. Murray, of Overstone, thus states the expense of

* Five pounds of linseed will make about seven gallons of gruel, and suffice for five good-sized calves; considerable allowance must, however, be made for differences of quality in the linseed, that from India not being gelatinous enough, and therefore boiling hard, instead of "coming down kindly."

rearing the calf until it is two years old, when, after the weaning process is completed, it is turned out to grass :—

During the summer they have the run of a grass paddock during the day, but return regularly to their yards at night ; the following winter they are kept in larger yards, and which contain a greater number of animals. Their bill of fare for this winter is 2 lbs. of oil-cake, half a bushel of cut roots, with cut chaff *ad libitum*. The chaff has a small quantity of flour or pollard mixed with it, is moistened with water, and the whole mass turned over ; this is done the day previous to using it. By this means they eat the chaff with more relish, and moistening it prevents the flour being wasted. They are put to grass the following summer, generally from the 15th to the 20th of May, or as soon as the pastures are in a state to receive them ; they remain there on second-rate land till about the end of October, when they are brought home and tied up in the stalls. The daily allowance is then 4 lbs. linseed-cake, 4 lbs. flour—¾ bean, ¼ barley—1 bushel of cut roots with cut chaff ; the flour and chaff is mixed as already described. At about the end of December the quantity of cake is increased to 8 lbs., and the flour to 6 lbs. ; this they continue to receive till they are sold to the butcher during the months of March and April, when they weigh, on an average, 90 stones of 8 lbs. per bullock, and under two years and six months old. At this season of the year beef generally makes 5s. per stone—we often make 9s.—but taking that as an average would make the value of each beast £22 10s. The cost of keeping to this age will be as follows :—

	£	s.	d.
One calf	2	0	0
Milk, &c., nine weeks	1	5	0
Cake, grass, &c., forty-three weeks, at 1s. 6d.	3	4	6
Second year, November till May, cake, flour, roots, &c., 2s. 6d. per week, for twenty-six weeks	3	5	0
May till November, grass, twenty-six weeks, at 2s. 6d.	3	5	0
Third year, November till April, twenty weeks, at 8s.	8	0	0
	£20	19	6

Which leaves a gain to each animal of £1 10s. 6d., besides the manure.

Shelter of Stock.—The great diminution of temperature, and the falling off in the supply of herbage, that are coincident

with the close of the autumn, render it necessary to remove our cattle from the open fields, and provide them with some sort of shelter during the winter months and early part of the spring.

The particular period at which this change of quarters takes place of course varies, and is, in fact, altogether dependent upon the character of the season. There are some years in which there is, so to speak, a kind of relapse of the summer, November being bright and warm, instead of, as is usually the case, cold and foggy. In such a year there is some herbage to be picked up until the very end of December. On the other hand, the latter part of October is often very wet, and October frosts are by no means uncommon. Tempestuous, biting winds in November, or torrents of rain, or both, tell severely upon the poor animals in the fields, even where there is abundance of herbage; and hence, should such weather take place at the latter part of October, the true economy would be to remove the animals at once to sheltered places.

Nothing lowers the temperature of the surface so rapidly as a cold wind. Captain Parry, one of the explorers of the Arctic regions, states that his men, when well clothed, suffered no inconvenience on exposure to the low temperature of 55 degrees below zero, provided the air was perfectly calm; but the slightest breeze, when the air was at this temperature, caused the painful sensation produced by intense cold. I could adduce the experience of many practical men in favor of the plan of affording shelter to animals, but more especially to those kept in situations much exposed to winds. Mr. Nesbit relates a case bearing on this point:—A farmer in Dorsetshire put up twenty or thirty sheep, under the protection of a series of upright double hurdles lined with straw, having as a sort of roof, or lean-to, a single hurdle, also lined with straw. A like number of sheep, of the same weight, were fed in the open field, without shelter of any kind. Each set was fed with turnips *ad libitum.* The result was, that

those without shelter increased in weight 1 lb. per week for each sheep, whilst those under shelter, although they consumed less food, increased respectively 3 lbs. per week.

As a general rule, the latter part of October, or early in November, is the time for the removal of live stock from the pastures to the shelter of the farmstead. In England and Scotland the transference is seldom delayed after these dates; but in Ireland it is no uncommon thing to see the animals grazing very much later in the year—a circumstance which the lateness and mildness of our climate account for. But whatever the date may be, the importance of such shelter is universally recognised, even by those who most neglect it and are least acquainted with the principles upon which its necessity depends. The more important of these principles have already been explained, but they may be here summarised as follows:—

1. A certain amount of warmth is an indispensable condition for the maintenance of the life of animals.

2. The internal heat of the bodies of animals is supplied by the chemical combination which takes place between the oxygen of the atmospheric air which they inspire and certain of the constituents (carbon and hydrogen) of the food which they consume, or, to speak more accurately, of the tissues of their bodies, which are formed out of their food. It is very much in the same way in which our houses are heated by the burning of coal, turf, or wood in their fire-places, since the heat derived in the latter case is obtained from a similar source as in the former one—namely, by the union of the oxygen of the air with the carbon and hydrogen of the fuel. The only real difference between the two kinds of combustion is, that in respiration the process is conducted with an extreme degree of slowness, whilst in the ordinary fire the combinations take place rapidly, and the heat being evolved in a much shorter time is proportionately the more intense.

3. The temperature of the external parts of the animal body varies with the nature and quantity of the food supplied to it, and also depends upon the state of the weather and the character of the protection afforded to it.

The colder the air, the greater will be the quantity of food required, and the more complete the shelter. In other words, a diminution of temperature, no matter how caused, will necessitate an increased amount of food and more perfect shelter, in order to maintain at the proper degree of heat the fluids of the body. It is only the external parts of the body that become cold: so long as the animal is in health its blood always maintains the same degree of temperature; but in cold weather the blood is subjected to a greater cooling power than it is in warm weather, and this cooling power it can only resist by taxing more extensively the heat-producing resources of the body.

4. Exposure to wet, even in warm weather, will tend to reduce the temperature of the body, since the conversion of water into vapor can only be effected at the expense of heat, which heat must be in great part extracted from the body of the animal itself.

5. No possible increase of food, however nutritious it may be, can suffice to keep up the due warmth and healthy condition of the animal frame in winter, if shelter from cold and rain be not simultaneously effected. On the contrary, an animal well protected from the winter blasts will require much less food than if it were placed in an exposed position. The reason of this is, that the amount of food which an animal exposed to great cold consumes to maintain the temperature of its body would, under opposite conditions, be stored up in the form of permanent "increase"—beef or mutton for the butcher, in fact.

The fat-forming constituents of the food of stock are in no case converted into permanent fat, except when they exceed in quantity the amount required to keep up the internal heat of the animal; but when this is constantly reduced by exposure

to a wintry temperature, the food becomes insufficient for even that purpose, no matter how much aliment is given. What, then, must not be the condition of the unfortunate animals whose fate it is to be the property of a farmer who neither shelters them from the weather nor provides them with a sufficient quantity of nourishing food!

Milch Cows.—When dairy-farming is conducted on pure pastures, the cows are altogether dependent upon the grasses; and in winter, the animals suffer much from scarcity of food. This is the very worst system of cow-keeping, but it is prevalent amongst many small farmers in Ireland, and is to be met with even in England and Scotland. I am strongly of opinion that it would be far more economical to keep cows (and other cattle) altogether in the house, and feed them with cut grass, than to allow them to remain out altogether in the field. There are several disadvantages resulting from the depasturing of cows. In the warm weather, the animals are greatly annoyed by the attacks of flies: there is a considerable waste of muscle, caused by the movements of the animals whilst in search of their food; and the excrements of the animals and their footmarks injure a large portion of the grass. It may be somewhat troublesome and expensive to cut the grass, and convey it from the field to the house; but the labor and the cost will be more than repaid by the greatly-increased yield of food. A grass-field, mowed, will produce from 20 to 30 per cent. more food than it would if it were trampled upon and soiled by cattle. Exercise for an hour or two in the cool of the evening, or early in the morning (during the hot weather), will be quite sufficient to keep the animals in health. This may be taken in a field, better in a paddock, best of all in a roomy yard. When cattle are supplied with cut grass, or clover, care should be taken not to give it to them when very wet, for otherwise there is danger of the excessively moist herbage producing the *hoove.* Neither should large quantities of the green food be given to them—the supply should be "little and often." Should the food be too succulent, the addition of a

little straw will correct its laxative effects. When the stock is about passing from the winter keep to summer food, the transition should be gradual; a well-made compound of straw or hay with grass (natural or artificial) is much relished by cows. A supply of good water is absolutely necessary; but sufficient attention to this important point is seldom given. Cooked food is well adapted for milch cows. Mangels, kohl-rabi, and cabbages are each of them better food than turnips, as the latter is apt to impart a disagreeable flavour to the butter. Three feeds in the day is a sufficient number for cows. The first meal should be early in the morning, and may consist of roots, mixed with straw or hay. Some feeders prefer using dry fodder, or cooked food of some kind, and not raw roots. The second meal is given at mid-day, and the third in the evening. The daily allowance of roots varies from 2 to 8 stones, depending upon the quantities of other foods used. Mr. Horsfall's diet is as follows:—Hay, 9 lbs.; rape-cake, 6 lbs.; malt-combs, 1 lb.; bran, 1 lb.; roots, 28 lbs. These substances are mixed and cooked, and the animals receive them in a warm state. In addition to this food, Mr. Horsfall's cows get bean-meal—a cow in full milk 2 lbs., others from ½ lb. to 1½ lbs.; cost per week per cow, 8s. 7d.* Mr. Alcock, of Skipton, feeds his cows as follows:—Raw mangels, 20 lbs.; carob beans, 3 lbs.; bran and malt-combs, 1¾ lbs.; bean-meal, 3½ lbs.; rape-cake, 3 lbs.; per diem. A steamed mixture of wheat and bean straws and shells of oats *ad libitum.* Oats, to the extent of 2 or 3 lbs. daily, are an excellent food for cows.

An important point in dairy economics is the feeding of the cows at *regular* intervals. If the usual time for the feed be allowed to pass, the animals are almost certain to become very uneasy—to *worry;* and every feeder knows, or ought to know, that a fretting beast will neither fatten nor yield milk satisfactorily. The cow-house ought to be kept as clean as

* "Journal of the Royal Agricultural Society," vol. xxxix.

possible; and the excreta, therefore, should be removed several times a day.

Mr. Harvey, of Glasgow, has probably one of the largest dairies in the world. His cow byres, 56 yards long, and from 12 to 24 feet wide—according as one or two rows of cows are to be accommodated—stand closely packed, the whole surface of the ground being thus covered by a kind of roof. From 900 to 1,000 cows are constantly in milk. They are fed during winter partly on steamed turnips (7 tons being steamed daily in order to give one meal daily to 900 cows), partly on coarse hay, of which, as of straw, they get between 20 and 30 lbs. a day each. They are also fed on draff, of which they receive half a bushel daily each; on Indian-corn meal, of which they have 3 lbs. daily each; and on pot-ale, of which they receive three times a day nearly as much as they will consume, *i.e.*, from 6 to 10 gallons daily. During the summer they are let out, a byreful at a time, for half a day to grass, and on coming in receive their spent malt and still liquor, and hay in addition. They are managed, cleaned, and fed by two men to each byre holding about 100 cows. The milking is done three times a day, by women who take charge of 13 cows in full milk, or double that number in half milk, apiece. Between 4 and 5 o'clock a.m. (taking the winter management), the byres are cleaned out, and the cows receive a "big shovelful" of draff apiece, and half their steamed turnips and meal, and a "half stoupful," (probably 2 gallons) of pot-ale. They are milked very early. At 7 they receive their fodder-straw or hay. At 10 they get a "full stoupful" (probably 3 or 4 gallons) of pot-ale. They are milked at noon. At 2 p.m., or thereabouts, they are foddered again, and at 4 p.m. receive the same food as at the morning meal. They are again milked at 5 to 6, cleaned out and left till morning. The average produce is stated to be 2 gallons a day per cow.

Mrs. Scott, of Weekston, Peebles, who keeps one of the best managed dairy farms in the United Kingdom, thus con-

ducts her operations in the winter :—At 6 o'clock in the morning the cows are well wiped or scrubbed, have their bedding removed, and receive each about 4 or 5 lbs. of straw. At 8 o'clock the cows are milked, and Mrs. Scott examines each to ascertain whether or not the milk-maid has left any fluid in the udder—and woe betide the careless maid if her work has been carelessly done! At 10 o'clock a barrowful of turnips is divided amongst three cows, and when these roots are not available, a quantity of peas or bean meal, with a pint of cold water, takes their place. At 1 o'clock the cows are allowed out to be watered, and during their absence from the byre it is thoroughly cleansed and ventilated. When the state of the weather prevents the cows from being turned out, they receive twice a day a handful of oatmeal diffused throughout three pints of water—a handful of salt being given in the first of these drinks. When the cows return to the byre, they receive each about 4 or 5 lbs. of straw, and at 4 or 5 o'clock an evening meal of turnips equal to their morning feed. At 8 o'clock a "windling" of meadow hay is given to each pair of cows, the quantity being always regulated according to the requirements of each cow. The cows upon calving receive, in addition to this allowance of hay, half a pailful of boiled turnips, mixed with a quart of peas or bean-meal. This mess is given in a lukewarm state. Mrs. Scott's system may be thus epitomised: Regularity in feeding; sufficient but not excessive food; regularity in milking; and minute attention to cleanliness and ventilation.

Stall-feeding.—What becomes of the 90 per cent. of the weight of the non-nitrogenous constituents of the food of the sheep, and of the 80 per cent. of that of the nutriment of the pig, which they consume but do not store up? I have already partly answered this question. This portion of the food is chiefly expended in the production of the heat with which the high temperature of the animal's body is maintained. Part of it, no doubt, passes unchanged through its body, either owing to its indigestibility, or to its being given in excess. The

quantity of non-nitrogenous matters consumed by a man is influenced greatly by the temperature of the air which he habitually breathes, and by the nature of the artificial covering of his body; there may be other conditions at present unknown to us, but these are amongst the chief ones. Now, as there is sufficient reason to lead us to believe that the consumption of carbonaceous food by the lower animals is influenced in the same way by the temperature of the medium in which they exist, the question naturally suggests itself, would it not be cheaper to maintain the heat of the animal by burning the carbon of cheap coal or turf outside its body, than by consuming the carbon of costly fat within it? The answer to this question is not so simple as at first sight it appears to be. We must not consider that, because 10 lbs. weight of carbon, as coal, costs but a penny, whilst an equal weight of the same element in starch costs twenty pence, heat may be furnished to a fattening animal twenty times cheaper by the combustion of coal than by that of starch. No doubt the amount of heat evolved by the conversion of a pound-weight of carbon into carbonic acid is the same, whether it be a constituent of starch or of coal; but the application of the heat so produced is less under our control in the latter case. All the heat evolved during the combustion of the starch within the animal's body is made use of; whilst a very large proportion of that developed by the combustion of coal in a furnace cannot in practice be applied to the purpose of heating the animal's body.

It is only the handiwork of the Creator which is perfect, and no machine constructed by the skill of man, for the direction of force, can rival that wondrous heat-producing, force-directing mechanism — the animal organism. According to Dumas, the combustion of about 2½ lbs. of carbon in a steam-engine is required to generate sufficient force to convey a man from the level of the sea to the summit of Mont Blanc; but a man will ascend the mountain in two days, and burn in his mechanism only half a pound of carbon. There is no machine

in which heat and force are more completely made available than the animal organism; and were it not—thanks to the influence of antediluvian sunshine—that the carbon of fuel in these countries is so very much cheaper than the carbon of food, there is no doubt but that the cheapest mode of keeping an animal warm would be to allow it to burn its carbon within its body. As the matter stands, however, there is no question as to the advisability of keeping fattening animals in a warm place. If the temperature of the stall be equal to that of the animal's body there will be less food consumed in the increase of its fat; because less of the fat-forming materials will be expended in the production of heat. In this sense, therefore, heat is an equivalent to food, but only within certain limits; because heat is developed in large quantity within the animal body independently of the temperature of the air. There is, therefore, no object to be attained by having the stalls heated beyond 70 or 80 degrees. Indeed, it is to be questioned whether or not stalls artificially heated are ever properly ventilated. If they be not, the health of the animal will suffer, and its appetite—so essential a point in fattening stock—will become impaired. We may conclude—firstly, that animals, when fattening, should be kept at a temperature not under 70 degrees nor above 90 degrees Fahrenheit; secondly, that the mode of heating must be such that there is as little wasteful combustion of fuel as is possible under the circumstances; and, lastly, that no motives of economy of fuel should prevent the feeding places from being thoroughly ventilated.

Stall-feeding is not so extensively carried on in Ireland as it is in Great Britain. There is a general impression that it does not pay in the former country; but if such be the case, it is simply owing to the want of skill on the part of the Irish feeders.

The cattle intended for stall-feeding should be removed (if out) from the field in October, and put into the house, or court, or crib, or hammel, as the case may be. They are fed upon roots, straw, hay, grain, and artificial food. The greatest skill is required in their treatment. It is a nice point to deter-

mine which foods are the most economical, and also to ascertain in what foods excessive proportions of certain nutritive elements exist. Sufficient food should be given; but any approach to waste should be avoided. Three feeds a day are usually given, and should be supplied at the same hours each day. For about two weeks the animals are furnished with white turnips *ad libitum;* but after the expiration of that time they receive Swedish turnips, straw, and grain, or oil-cake. Late in the season mangels will replace turnips. Almost every extensive feeder now uses oil-cakes in large quantities; but when oats are low in price, they will in general be found a cheap equivalent for a large proportion of the oil-cake. Different feeders have different dietaries, and the nature of the aliments supplied to fattening stock depends very much upon the market prices of food-stuffs, and the locality in which the feeding-house is situated. The following dietaries are but examples of the methods of feeding adopted in different districts and by different persons :—

Mr. McCombie, of Tillyfour, fattens from 300 to 400 beasts annually, and obtained for them in 1861 £35 per head. He never exceeds 4 lbs. of oil-cake per diem, nor 2 lbs. of bruised oats, for each beast. He gives as much turnip and straw as they can consume. He realises £12 per acre in feeding on Aberdeen and Swedish turnips.

"For fatting cattle," says Mr. Edmonds, of Cirencester, "I should recommend two parts hay and one part straw, or in forward animals three parts hay and one part straw cut in chaff. Those of average size will eat somewhere about five bushels per day, with 4 lbs. to 5 lbs. oil-cake, and half a peck of mixed meal, barley and peas, or beans, and, if cheap, a proportion of wheat also, to be increased to one peck per day in a month or six weeks after they have come to stall, the oil-cake and meal to be boiled in water for half-an-hour or three-quarters, and thrown in the form of rich soup over the chaff, and well mixed, to which add a little salt."

Colonel M'Douall, of Logan, Wigtonshire, gives 3 lbs. of

bean-meal and 3 lbs. of cut straw cooked together, and 84 lbs. of Swedish turnips.

According to the researches of Messrs. Lawes and Gilbert, an ox weighing 1,400 lbs. ought to gain 20 lbs. weekly when fed under cover with 8 lbs. of crushed oil-cake, 13 lbs. of chopped clover hay, and 47 lbs. of turnips. The chemical constituents (in a dried state) of this allowance are as follows:—

	Ounces.
Fat-formers, or heat givers	232
Flesh-formers	55
Mineral matter	29

Cost of Maintaining Animals.—The animal mechanism, which exhibits the least tendency to fatten, is the most costly to keep in repair, in relation to the work performed by it. If, for example, a sheep store up in its increase one-fifth of its food, then the remaining four-fifths are expended in preserving it alive, and their cost represents, so to speak, the expense of preserving the animal's body in repair. If another sheep store up only one-tenth of its food, then the cost of its maintenance may be said to be double that of the animal which retains the larger proportion of its nutriment in the form of flesh. Of course in both cases the value of the manure will to a great extent compensate for the cost of the food expended in merely keeping the animal alive; but that does not affect the proposition, that the less food expended by an animal in carrying on its vital functions the more valuable is it as a "meat-manufacturing machine." From the moment it is brought into the world until it is "ripe" for the shambles, an animal should steadily increase in weight: every week that it does not store up a portion of its food in permanent increase is the loss of a week's food to the feeder; for all the fodder consumed during that time by the animal is, so to speak, devoted to its own private purposes. Sheep overcrowded on pastures, milch cows on "short commons," calves kept on bulky innutritious food, are all so many sources of positive loss to the feeder—and as many proofs that he who aspires to

be a successful producer of meat, must, in one respect at least, be a devout believer in the doctrine of Progressive Development.

Cooking and Bruising Food.—The cooking, or the otherwise preparing, of the food of the domesticated animals is a subject which until recently was completely ignored by the vast majority of stock feeders. It is now, however, beginning to attract a fair amount of attention; and no doubt ere long the best modes of treating the food of cattle will be discovered.

As might be expected from our limited experience of the subject, there exists considerable difference of opinion relative to the proper method of cooking cattle food; and there are many very extensive feeders who object to the plan altogether, and contend that as the food of the inferior animals is naturally supplied to them in a raw condition, it would be quite unnatural to give it to them in a cooked state.

Whatever difference of opinion there may be with regard to the propriety of cooking the food of stock, we believe there ought not to be a doubt as to the desirability of mechanically treating the harder kinds of feeding stuff. It is quite evident that a horse fed upon hard grains of oats and wiry fibres of uncut hay or straw must expend no inconsiderable proportion of his motive power in the process of mastication. After a hard day's work of eight or ten hours he has before him the laborious task of reducing to a pulp from 12 lbs. to 20 lbs. weight of exceedingly hard and tough vegetable matter; and as this operation is carried on during the hours which should be devoted to rest, the repose of the animal is to some extent interfered with. Indeed, it not unfrequently happens that a horse, after a hard day's work, is too tired to chew his food properly; he consequently bolts his oats, a large proportion of which, as a matter of course, passes unchanged through the animal's body.

In order to render fully effective the motive power of the horse, it is absolutely necessary to pay attention to the condition, as well as to the quantity and quality of his nutriment. The force wasted by a horse in the comminution of his food, when composed of whole oats and uncut hay and straw, cannot,

at the lowest estimate, be less than that which he expends in an hour of ordinary work, such as, for example, in ploughing. The preparation of his food by means of water or steam power, or even by animal motive power, would economise by at least 50 per cent. the labor expended in its mastication; and this would be equivalent to nearly half a day's work in each week, and, consequently, a clear gain of so much labor to the owner of the animal. In the present time of water-power and steam-power corn-mills, one man is able to grind the flour necessary for the support of several thousand men; in early ages the labor of one person in the grinding of wheat served but to supply the wants of twenty others. In both cases machinery was employed for reducing the grain to flour; but in the one case, the mechanisms employed were more than a hundred times more effective than in the other. But even the most imperfect flour mill is by far a more economical system of comminuting corn than the jaws of animals; and if every man were obliged, as the horse is, to grind his corn by means of his teeth alone, he would find his powers for the performance of other kinds of labor considerably lessened.

It has been urged as an objection to the use of bruised oats by horses, that they exercise in that state a laxative influence upon the animal's bowels. I doubt very much that such is frequently the case, when the animal is fed only upon oats and hay and straw; but even if the oats produce such an effect, the addition of a small proportion of beans—the binding properties of which are well known—will obviate the disadvantage.

The desirability of mechanically acting upon soft food is not so apparent as the necessity for the bruising of oats is. Roots are so easily masticable that if they are rendered more so there is danger of their being so hastily swallowed as to escape thorough insalivation, which is so necessary to ensure perfect digestion. To guard against this danger, perhaps the best way would be to give pulped mangels and turnips mixed with cut straw; a mixture which could not easily be bolted. Mr. Charles Lawrence, of Cirencester, who is a great advocate

for the cooking of food, and has frequently published his experience of the benefits derivable therefrom, thus describes his method of combining pulped roots with dry fodder :—

We find that, taking a score of bullocks together fattening, they consume per head per diem three bushels of chaff, mixed with just half a cwt. of pulped roots, exclusive of cakes of corn ; that is to say, rather more than two bushels of chaff are mixed with the roots, and given at two feeds, morning and evening, and the remainder is given with the cake, &c., at the middle-day feed, thus:—We use the steaming apparatus of Stanley, of Peterborough, consisting of a boiler in the centre, in which the steam is generated, and which is connected by a pipe on the left hand with a large galvanised iron receptacle for steaming food for pigs, and on the right with a large wooden tub, lined with copper, in which the cake, mixed with water, is made into a thick soup. Adjoining this is a slate tank, of sufficient size to contain one feed for the entire lot of bullocks feeding. Into this tank is laid chaff with a three-grained fork, and pressed down firmly; and this process is repeated until the slate tank is full, when it is covered down for an hour or two before feeding time. The soup is then found entirely absorbed by the chaff, which has become softened and prepared for ready digestion.

Mr. Wright, near Dunbar, gives the following account of an experiment with pulped roots and straw and oil-cake. It appears to prove the superiority of mixed foods over the same foods consumed separately :—

Two lots of year-old cattle were fed ; the one in the usual way—sliced turnips and straw, *ad libitum*—the others with the minced turnips, mixed with cut straw. The first lot consumed daily 84 lbs. sliced turnips, 1 lb. oil-cake, 1 lb. rape-cake, ½ lb. bean-meal, broken small and mixed with a little salt, and what straw they liked. The second lot ate, each, daily, 50 lbs. minced turnips, 1 lb. oil-cake, 1 lb. rape-cake, ½ lb. bean-meal, and a little salt, the whole being mixed with double the bulk of cut straw or wheat chaff. In spring, the lot of cattle which had the mixed food were in good condition, and equally well grown as others, though they had consumed in five months two tons less of roots apiece. The reporter does not advise the mincing process to be commenced when cattle are very forward in condition, as any change of food requires a certain time to accustom the animals to it, and in the meantime fat cattle are apt to fall off in condition. It ought to be begun when they are young and lean.

Mr. Duckham, of Baysham Court, Ross, Herefordshire, says :—

The advantages of pulping roots for cattle are—1st, Economy of food; for the roots being pulped and mixed with the chaff, either from threshing or cut hay or straw, the whole is consumed without waste, the animals not being able to separate the chaff from the pulped roots, as is the case when the roots are merely sliced by the common cutter, neither do they waste the fodder as when given without being cut.

2. The use of ordinary hay or straw. After being mixed with the pulp for about twelve hours, fermentation commences, and this soon renders the most mouldy hay palatable, and animals eat with avidity that which they would otherwise reject. This fermentation softens the straw, makes it more palatable, and puts it in a state to assimilate more readily with the other food. In this respect I think the pulper of great value, particularly upon corn farms where large crops of straw are grown, and where there is a limited acreage of pasture, as by its use the pastures may be grazed, the expensive process of haymaking reduced, and, consequently, an increased number of cattle kept. I keep one-third more, giving the young stock a small quantity of oil-cake, which I mix with the chaff, &c.

3. Choking is utterly impossible, and I have only had one case of hoove in three years, and that occurred when the mixture had not fermented.

4. There is an advantage in mixing the meal with the chaff and pulped roots for fattening animals, as thereby they cannot separate it, and the moisture from the fermentation softens the meal and ensures its thorough digestion, whereas, when given in a dry state without any mixture, frequently a great portion passes away in the manure.

On the value of the process for a grazing farm with but a small quantity of plough-land, Mr. Corner, of Woodlands, Holford, Bridgewater, thus speaks :—

My plan is, first commencing with the grazing beasts, to cut about an equal quantity of hay and straw and mix with a sufficient quantity of roots (mostly mangel) to well moisten the chaff; and as the beasts advance in condition, I lessen the straw and increase the hay, and in their further progress I mix—in addition to all hay, chaff, and roots—from 6 to 10 lb. per day to each bullock of barley and bean-meal, according to its size—and I have them large sometimes. I sold last week for the London market a lot of Devon oxen of very prime quality, averaging in weight upwards of 100 stone imperial each.

For my horses, cows, yearlings, and oxen—the latter to be kept in a thriving condition, and turned to grass, and kept through the summer for Christmas, 1860—I cut nearly all straw, with a very small quantity of hay, and this the offal of the rick. These also have as many pulped roots as will moisten the chaff, except the horses, and to them I give, along with bruised oats, just enough roots to keep their bowels in a proper condition.

To the two or three-year-old beasts I give some long straw and a part chaff, and the offal (if any) of the food of the above lots of stock.

My farm is but a small one—under 200 acres. My predecessor always mowed nearly all the pastures for hay, which is about half the farm, and with this scarcely ever grazed any beasts, and kept but very few sheep. Since my occupation I scarcely ever exceed ten acres of meadow with one field of seeds for hay. I keep from 250 to 300 large-size Leicester sheep, and graze from 20 to 25 large-size beasts a year, with other breeding stock in proportion.

I consider the pulping of roots is better for fatting pigs than anything else. My plan is to have a large two-hogshead vat as near the pulping machine as possible, so as to fill it with a malt shovel as it comes from the machine; at the same time I keep a lad sprinkling meal (either barley or Indian corn) with the roots; and this is all done in fifteen or twenty minutes. It is then ready for use, to be carried to the pigs in the stalls alongside the fatting beasts. I never could fatten a pig with profit until I used pulped roots.

Although the practice of cooking food has been advocated by several eminent feeders, it has been condemned by others. Mr. Lawes is not favorable to the cooking of food unless when it is scarce. The results of Colonel M'Douall's experiments go to prove that cattle can be more economically kept upon a mixture of raw and cooked foods than upon either raw or cooked fodder given separately. One meal of cooked food and two feeds of raw turnips gave better results than three feeds of raw turnips; whilst two cooked feeds and a raw one resulted in a loss.

The fermentation of food, if not the best, is certainly the cheapest mode of preparing it. If the process be not pushed too far the loss of nutriment sustained is inconsiderable. When a mixture of straw and roots is fermented, the hard fibres of the latter are, to a great extent, broken up, and the nutrient particles which they envelop are fully exposed to the action of the solvent juices of the stomach.

A great advantage in cooking or fermenting food is that the most rubbishy materials can be used up. Indeed, as a general rule, the better soft food is, the less the necessity for cooking it; but washed out hay and hard, over-ripened straw are of but little value, except when cooked and given in combination with some agreeably-flavored substance.

VALUE FOR FEEDING PURPOSES OF VARIOUS FOODS.*

MATERIAL.	Cost. Per ton.	Cost. Per 100 lbs.	100 lbs. contain. Oil.	Starch, Sugar, &c.	Oil, Starch, &c., computed as Oil.	Nitrogen. Weight.	Nitrogen. Value.	Phosphoric Acid. Weight.	Phosphoric Acid. Value.	Potash. Weight.	Potash. Value.	Value of Nitrogen, Phosphoric Acid, and Potash.	Deduct Nitrogen for perspiration.	Net Value for Manure.
	£ s. d.	s. d.	lbs.	lbs.	lbs.	lbs.	d.	lbs.	d.	lbs.	d.	s. d.	d.	s. d.
Meadow-hay ...	4 0 0	3 7	2·68	39·75	24·63	1·48	10·62	0·90	1·35	1·50	4·50	1 $4\frac{1}{2}$	$2\frac{1}{12}$	1 $2\frac{1}{4}$
Wheat-straw ...	1 15 0	1 7	0·50	32·0	18·50	0·42	3·0	0·14	0·21	0·65	2·16	0 5	$\frac{1}{2}$	0 5
Swedish Turnips	4 10 0	4 0	2·0	60·0	35·0	2·40	17·28	0·80	1·20	2·25	6·75	2 $1\frac{1}{4}$	$3\frac{1}{2}$	1 $9\frac{3}{4}$
Oil-cake	9 6 8	8 4	12·0	38·0	33·0	5·0	36·0	2·25	3·37	1·75	5·25	3 $8\frac{1}{2}$	$7\frac{1}{4}$	3 $1\frac{3}{4}$
Beans	9 6 8	8 4	2·0	42·0	25·30	4·45	32·0	0·86	1·29	1·11	3·33	3 $0\frac{1}{2}$	$6\frac{1}{2}$	2 6
Indian Meal ...	9 6 8	8 4	7·0	60·0	40·0	2·25	16·20	0·19	0·28	0·17	0·51	1 5	$3\frac{1}{4}$	1 $1\frac{3}{4}$
Carob, or Locust Bean.........	9 6 8	8 4	6·76	57·0	35·0	0·64	3·75	No analysis of ash.				say $5\frac{3}{4}$	—	0 5

* From Mr. Horsfall's Essay on Dairy Management, in "Journal of Royal Agricultural Society," vol. xviii., part i.

Bedding Cattle.—Instead of wasting straw in bedding cattle, it would be much better to pass it through their bodies. If straw must be used for litter, let it be employed as economically as possible. Good substitutes, wholly or in part, for straw bedding may be found in sawdust, ashes, tan and ferns. Leaves of trees if procurable in quantity constitute an excellent litter.

SECTION II.

THE SHEEP.

THE management of sheep varies greatly—depending upon the breeds of the animal, the localities in which they are reared and fattened, and various economic conditions. The tupping season varies of course with the country: in Ireland it commences about the middle of September and lasts for two months; in England and parts of Scotland, the season is about a month earlier. The best kinds of sheep admit of being very early put to breed. Both ram and ewe are ready for this purpose when about fifteen months old. One ram is sufficient for about 80 ewes. The breeding flock should be in a sound, healthy condition, and the ram ought to be as near perfection as possible. The condition of the sire ought to be good, but at the same time it is not desirable to have him over fat. The more striking indications of good health in the sheep are dry eyes, red gums, sound teeth, smooth, oily skin, and regular rumination. The color of the excreta should be natural.

Breeding Ewes.—After the tupping season, which generally lasts for a month, the sheep are usually put on a pasture, which need not be very rich. In cold situations ample shelter should be afforded to the breeding flocks; and in severe weather they should, if possible, be removed to sheds. When snow covers the ground, the animals must be supplied with turnips, or cooked food of some kind. At such time a little oil-cake will be found very useful.

Yeaning.—In March the yeaning season sets in; and as this time approaches, the food of the animals should be improved, and the greatest care must be taken of them. The shepherd should be unceasing in his watchfulness, frequently examining every individual animal. The lambing, if possible, ought to take place in sheds, or some covered place.

Rearing of Lambs.—Delicate lambs require great care. Very weak ones often require to be hand fed. Should a mother die, her offspring may be placed with another ewe; on the other hand, should a lamb perish, its mother may be appointed to rear one of another ewe's twins (if such be available). The ram lambs, not intended for breeding purposes, are subjected to a necessary mutilation when they are about three weeks old. If this operation be performed later, there is great danger that fatal inflammatory action may set in; on the other hand, a lamb much younger than three weeks is hardly strong enough to bear the pain of the operation. The tails of the lambs are shortened about the same time; but it would be better in the case of the rams not to perform both operations on the same day. These operations are best performed during moist or cloudy weather; if they must be done on frosty or stormy days, the lambs should be kept under shelter for two or three days, as otherwise the cold might induce inflammation. The lambs remain with their mothers for about four months, after which they are weaned, and put upon a good pasture. When the herbage is poor, oil-cake, say $\frac{1}{4}$ lb. daily, or some other nutritious food, should be used to supplement it. During the summer and part of the autumn the young stock, as a rule, subsist upon grass; but many flock-masters give them other kinds of food in addition. As winter approaches, the young sheep on tillage farms receive soft turnips, and sometimes a little hay or straw. The allowance of oil-cake may be increased to $\frac{1}{2}$ lb., or if corn be cheap, it may be substituted for the oil-cake. After Christmas Swedish turnips are used.

Mr. Mechi gives the following information on the subject of rearing lambs during a season when roots are scarce:—

Two hundred lambs, which cost 22s. 6d. each on September 12th, were kept on leas and stubble until November 3rd, then on turnips until December 19th, when fifty of them were drafted to another flock getting a little cotton-cake. On the 3rd of February fatting commenced with linseed-cake in addition to cut Swedes. On the 7th of April the fifty tegs were put on rye with mangels, and they were sold on the 4th of May at 61s. each.

The remaining 150 lambs were wintered as stores at little cost, on inferior turnips uncut; they were put on rye from March 8th till May 4th, when they were valued at 48s. each.

The district just referred to became so exhausted of its stock, that at some of the later fairs the number of lambs and of ewes exhibited was less than one-fourth of the average. But in Essex, on six adjoining farms, including that from which I write, the number of sheep wintered has been greater than these heavy lands ever carried before. This has been effected by the extension of a system of management often practised on heavy land, that of eking out a scanty supply of green food by a liberal allowance of straw, chaff, and grain; which happily were good in quality, as well as plentiful and low in price in 1864.

By these means we were enabled last winter to keep 1,500 sheep on about 650 acres of arable, and 350 acres of dry upland pasture—chiefly park surrounding a mansion. The arable land does not very well bear folding in winter, as a preparation for spring corn. Neither climate nor soil are favorable to turnips, and notwithstanding our efforts in assisting Nature, our crops of turnips, rape, or Swedes, are never first-rate, and sometimes very bad. Strong stubbles, good beans, clover-seed, and mangel, are the specialities of the locality, and they indicate heavy land, corn-growing, and yard-feeding. Sheep have been generally "conspicuous by their absence," though even the heavy-land farmer is glad to winter a yard of them instead of cattle, that he may keep some, at least, of the stock that pays best.

In the autumn of 1864 our root crops consisted of some white turnips and rape, eaten by the ewes in September, and of a very bad crop of mangel, the whole of which was reserved for the ewes at lambing-time. In this predicament we wintered about 1,000 half-bred lambs, more than 400 ewes, and some fatting sheep. All, except the fatting sheep, were folded on the stubbles, and allowed a daily run on the park of about an hour for each flock. The freshest grass was reserved for the ewes, and a very meagre bite remained for the lambs; in fact, except for a few weeks in autumn, the parks afforded them little or nothing except exercise and water.

The flocks were divided between three separate farms, and their food was prepared at the respective homesteads. The treatment was in every

respect similar; we shall therefore only notice in detail the management at one farm.

The following details are taken from our "Live Stock Book:"—

EXTRACTS FROM STOCK BOOK.

Lambs.

Payments. *November 4th*, 1864.	£	s.	d.	Remarks.
352 lambs, cost at date, 30s. 9½d. each ...	542	2	3	Total cost of keeping 352 lambs for 24 weeks, £298 4s. 3d.
Cost of keeping 24 *weeks to April* 21, 1865:—				Cost per head, 16s. 11d.
Corn and cake, as per granary book ...	245	16	9	Cost, food only, 14s. 11d.
Cutting 25 tons of chaff, at 6s.	7	13	0	Value of the manure, reckoned at one-fifth the cost of the corn and cake, £49 3s. 4d.
Grinding 96 qrs. 6 bshls. of corn, at 9d. ...	3	12	6	
Attendance, at 19s. 10d. per week	23	16	0	Cost of the lambs, per head, £2 7s. 8d.
Horse labor, at 6s. per week	7	4	0	
Coal, 3s. 2d. per week	3	16	0	Value of manure, per head, 2s. 10d.
Use of 21 troughs, at 3d. each per month ...	1	11	6	No charge made for the straw-chaff eaten on the land.
Use of 180 hurdles, at 1d. each per month ...	4	10	0	
1½ cwt. of rock salt ...	0	4	6	
	£840	6	6	

The tegs would probably have been sold at a profit in April; they were, however, put on grass and clover, and were fattened in the summer.

September 29*th.*—352 lambs in the parks, on a little cotton-cake and some oats, until November 4th, when they were folded on a wheat stubble. Gave them 5 bushels of meal daily, mixed with 468 lb. of straw chaff. Cost 3½d. each per week for meal.

December 20*th.*—Increased the food to 6½ bushels of meal and 1 bushel of oil-cake.

December 18*th.*—

	lb.
2¾ bushels of maize crushed and boiled	143
4½ bushels of mixed meal	200
1 bushel of oil-cake	50
	393

Cost $5\frac{1}{2}$d. per week for corn and cake; chaff, $2\frac{1}{4}$ lb. each, between these and the ewes, the lambs eating rather less than 2 lb. each.

Eight pounds of rock-salt licked up by the 352 lambs per week.

January 23rd.—The food was increased to $7\frac{1}{2}$ bushels of meal, 2 bushels of oil-cake, and 2 bushels of rape-cake.

Mixture of Corn.	
Wheat	4 parts.
Barley	4 ,,
Oats	2 ,,
Maize	4 ,,

Cost per stone (14 lb.)	*s.*	*d.*
Wheat	1	0
Barley	0	10
Oats	1	0
Maize	0	10
Oil-cake	1	$4\frac{1}{4}$
Rape-cake...	0	9

Sheep Feeding.—In Ireland sheep are often exclusively fed on grass; but in most cases the addition of other food is desirable, and more especially is it necessary during winter. When confined to roots, sheep, on an average, consume about 26 lbs. daily, unless when under shelter, which diminishes the quantity by from five to ten per cent. Some sheep on which Dr. Voelcker experimented were fed as follows :—

	lbs.	ounces.
Mangel wurzel	19	8
Chopped clover hay	1	$\frac{3}{10}$
Linseed cake	0	$4\frac{8}{100}$
Total	20	$15\frac{38}{100}$

On this diet four sheep were maintained from the 22nd of March until the 10th of May, a period of forty-seven days. The weights were as follows :—

	22nd Mar.	10th May.	Gain.
No. 1	153	$170\frac{1}{2}$	$17\frac{1}{2}$
No. 2	134	$151\frac{1}{2}$	$17\frac{1}{2}$
No. 3	170	187	$17\frac{1}{2}$
No. 4	136	155	19

This experiment shows that the sheep can increase in weight on a daily allowance of food, much less than is usually given to them; but it will be found that growing sheep will usually consume a greater quantity of food than that used by Dr. Voelcker's fattening animals.

Sheep washing is performed before the animal is shorn. It is a process which should never be neglected, as dirty wool is certain to bring a less price than the same quality would if clean. After being washed, sheep should be kept in dry pasture for about ten days in order to allow the loss of yolk removed by the washing to be repaired; they will then be in proper condition for the shearer.

Sheep Dips are used for the purpose of removing parasites from the animal's skin. They often contain arsenic, or bichloride of mercury (corrosive sublimate), which are very objectionable ingredients. The glycerine sheep dip, prepared by Messrs. Hendrick and Guerin, of London, is a safe mixture, as it is free from mineral poisons, whilst the tar substances which it includes, act as a powerful cleanser of the skin, without injuriously affecting the yolk of the wool.

SECTION III.

THE PIG.

In the breeding of pigs, as in the breeding of other kinds of stock, great care should be taken in the selection of both sire and dam. A good pig should have a small head, short nose, plump cheek, a compact body, short neck, and thin but very hairy skin, and short legs. The black breed is considered to be more hardy than the white; and pure—all black or all white—colors as a rule indicate the purest blood.

The sow should not be bred from until she is a year old, and the boar especially should not be employed at an earlier age. Although one boar is sometimes left with forty pigs and even a greater number, he will not be able to serve more than a dozen about the same time, if vigorous progeny be expected. The sow's regular period of gestation is 113 days; she can have two litters a year, and in each there are from five to fourteen young. Moderate sized litters are the best, the young of very

numerous ones being often weakly. The best time to rear young pigs is during the warm or mild parts of the year.

During gestation the sow should be liberally fed, but not with excessive amounts. The food at this time should rather excel in quality than in quantity ; but so soon as she begins to nurse, her allowance must be increased, and may be rendered more stimulating. For a week or so before farrowing, the sow ought to be kept alone. Its sty should not be too small—not less than 8 or 10 feet square—for pigs require good air in abundance as well as other animals.

The straw used for litter should neither be too abundant nor too long ; in the latter case some of the young might be covered by it, and escaping the notice of the sow, might unconsciously be crushed by the latter. If the young are very feeble, it may become necessary to hand-feed them. Some sows eat their young : and when they have this habit, the better plan is to cease breeding from them ; for it appears to be incurable. After parturition some bran and liquid or semi-liquid food should be given to the sow.

Young Pigs subsist exclusively on their mother's milk but for a short time. In two or three weeks they may receive skimmed or butter-milk from the dairy. At a month old such of them as are not designed for breeding purposes may be subjected to the usual mutilations; and at from five to six weeks old the young are weaned, and converted into *stores*.

Store Pigs, when young, are best fed upon skimmed milk, oatmeal, and potatoes, in a cooked state. When they are approaching three months old, they may be supplied with raw food, if the weather be warm; but in winter, cooked and warm food will be found the more economical. Cabbages, roots, potatoes, and all kinds of grain that are cheap are used in pig feeding. The number of meals varies from six or seven in the case of very young animals, to three in the case of those nearly ready for fattening. Store pigs should be allowed a few hours' exercise daily in a paddock, or field, or at least in a large yard.

The dietaries of store pigs vary greatly, for these animals being omnivorous readily eat almost every kind of food. Mr. Baldwin, of Bredon House, near Birmingham, an extensive pig breeder, gave (in 1862) stores the following allowance:—At three months old, a quart of peas, Egyptian beans, or Indian corn. He considered English beans to be too *heating* for young pigs. The animals were allowed the *run* of a grass field. On this diet the stores were kept until they were eight months old (increasing at the average rate of five pounds per week), after which they were allowed an extra half-pint of corn. He calculated the weekly cost as follows:—Dry food, 1s.; grass, 2d.; man's time, 1d.; total, 1s. 3d. These results yielded a profit of 1s. per week per pig, pork being at the time 6d. per lb. Some feeders give young store pigs half-a-pint of peas, mixed with pulped mangel, and the quantum of peas is gradually increased to one pint per diem. All kinds of food-refuse from the house are welcomed by the pig. Skins, dripping, damaged potatoes, cabbage, &c., may be given to them; but they should not be altogether substituted for the ordinary food-stuffs. Coal-dust, cinders, mortar rubbish, and similar substances are often swallowed by pigs, and sometimes even given to them by the feeder. In certain cases Lawes and Gilbert found that superphosphate of lime was a useful addition to the food of pigs. A little salt should invariably be given, more especially if mangels (which are rich in salt) do not enter into the animals' dietary.

Fattening Pigs.—For some time before store pigs are put up to be fattened, the quality and quantity of their food should be increased, for it is not economy to put a rather lean animal suddenly upon a very fattening diet. The sty should be well supplied with clean litter, and should be darkened. Three feeds per diem will be a sufficient number, and the remains (if any) of one should be removed from the trough before the fresh feed is put into it. The feeding trough (which should be made of iron) should be so constructed that the animals cannot place their fore feet in it. The pig is naturally a clean animal, and therefore it should be washed occasionally, as there is every

reason to believe that such a procedure will tend to promote the animal's health. It should be supplied with clean water.

In Stephen's "Book of the Farm," it is stated that two pecks of steamed potatoes, and 9 lbs. of barley-meal, given every day to a pig weighing from 24 to 28 stones, will fatten it perfectly in nine weeks. Barley-meal is largely used in England as food for pigs. It is given generally in the form of a thin paste, and in large quantities. Lawes and Gilbert found that 1 cwt. of barley-meal given to pigs increased their weight by 22½ lbs. Indian meal is fully equal, if it is not superior to barley-meal, as food for pigs; and for this purpose it is far more extensively employed in Ireland. Every kind of grain given to pigs should be ground and cooked. In Scotland pigs are often fattened solely on from 28 to 35 lbs. of barley-meal weekly, and mangels or turnips *ad libitum*. Pollard is a good food for pigs, being rich in muscle-forming materials; it is a good addition to very fatty or starchy food. A mixture of pollard and palm-nut meal is an excellent fattening food. Potatoes are now so dear, that they are seldom—unless the very worst and diseased kinds—used in pig feeding. They should never be given raw. The more inferior feeding-stuffs should be used up first in the fattening of pigs, and the more valuable and concentrated kinds during the latter part of the process.

SECTION IV.

THE HORSE.

The horse is subject to many diseases, not a few of which arise from the defective state of his stable. The best kinds of stables are large and lofty, well ventilated and drained, smoothly paved, and well provided with means for admitting the direct sunlight. The walls should be whitewashed occasionally, and for disinfecting and general sanitary purposes, four ounces of

chloride of lime (bleaching powder) mixed with each bucket of whitewash, will be found extremely useful.

Farm horses are kept in stalls, which should not be less than six feet wide, and (exclusive of rack and rere passage) 10 feet long. For hunters and thorough-breds, *loose boxes* are now generally used.

The mare commences to breed at four years, and the period of gestation is 340 days. She may be worked until within a fortnight of the time at which parturition is expected to occur. After foaling, the mare should be turned into a grass field (unless the weather is severe) and kept there idly for three or four weeks.

Foals are kept with their mothers until they are about five or six months old: after weaning, their food must be tender and nutritious—well bruised oats, cut hay, bean or oatmeal mashes; carrots are very suitable.

Working horses are fed chiefly upon oats and hay, which undoubtedly are the best foods for these animals, both being rich in muscle-forming materials. Bruised oats are far more economical than the whole grains: and if the animals eat too rapidly, that habit is easily overcome by mixing chopped straw or hay with the grain.

According to Playfair, a horse not working can subsist and remain in fair condition on a daily allowance of 12 lbs. of hay and 5 lbs. of oats. According to the same authority, a working horse should receive 14 lbs. of hay, 12 lbs. of oats, and 2 lbs. of beans.

Beans are a very concentrated food, rich in flesh-formers, and are, therefore, well adapted for sustaining hard-working horses. They are rather *binding;* but this property is easily neutralised by combining the beans with some laxative food. Turnips, carrots, furze, and various other foods are given to the horse, often in large quantities. The following are some among the many dietaries on which this animal is kept:—

Professor Low's formula is, 30 to 35 lbs. of a mixture of equal parts of chopped straw, chopped hay, bruised grain, and steamed potatoes.

The daily rations of horses of the London Omnibus Company, are 16 lbs. of bruised oats, $7\frac{1}{2}$ lbs. of cut hay, and $2\frac{1}{2}$ lbs. of chopped straw.

Stage coach-horses in the United States receive daily about 19 lbs. of Indian meal and 13 lbs. of cut hay.

Mr. Robertson, of Clandeboye, near Belfast, gives the following information on the subject of horse-keeping :—

The year we divide into three periods—October, November to May inclusive, June to September inclusive. During the first period, the horses get about 18 lb. of chaff and 12 lb. of crushed oats and beans ; "$10\frac{1}{2}$ oats and $1\frac{1}{2}$ beans" per head per day. During the second period they get about 15 lb. of hay chaff, 12 lb. ot crushed oats and beans, and about 3 gallons of boiled turnips per head per day. During the third period they were turned out to graze during the night. In the day time, whilst in the stable, each animal is allowed about 50 lb. of cut clover, and about 12 lb. of crushed oats and beans per day. The feeding is all under the charge of one person. He uses his own discretion in feeding the animals, though he is not allowed to exceed the quantities named. The horses to which I allude are the same on which the experiments commenced two years ago—six cart horses, one cart pony, and one riding horse. From Sept. 1, 1865, to and including August 31, 1866, the cost of maintaining these horses in good working condition ; keeping the carts, harness, &c., in repair ; shoeing, &c., was as follows :—

Oats, 14 tons, at 16s. per cwt.	£112	0	0
Beans, 2 tons, at 18s. per cwt.	18	0	0
Hay, 13 tons, at 30s. per ton...	19	10	0
Green Clover	15	0	0
Turnips...	5	0	0
Night grazing	18	0	0
Engine, cutting chaff, crushing oats, &c.	7	4	0
Attendance	26	0	0
Blacksmith	12	0	0
Saddler...	12	0	0
Carpenter	10	0	0
Five per cent. interest on value, £110	5	10	0
Depreciation in value 10 per cent.	11	0	0
	£271	4	0
Deduct cost of riding horse	35	0	0
	£236	4	0

£33 11s. 10d. per head; if we suppose the available working days to be 300, allowing 13 for wet days, holidays, &c., the daily cost will be 2s. 2½d.; to this if we add 1s. 8d., the wages of the driver, we shall have a total of 3s. 10½d. as the cost of a horse, cart, and driver per day. I would only add, in conclusion, that the horses are kept in good working condition; and, as a proof of their good health under this system, I may state that during the past two years we have not had occasion to require the services of a veterinary surgeon.

Musty hay or straw should not be given to horses. Furze is said to be a heating food; but it is very nutritious, and when young, may be given as *part* of the food of the horse.

Boiled turnips and mangels are often given in winter; but they are not sufficiently nutritious to constitute a substantial portion of the animal's diet. Oil-cake is occasionally given to horses; but seldom in larger quantities than 1½ lbs. per diem. On the whole, experience is in favor of occasionally giving cooked food to horses; and the practice meets with the full approval of the veterinarian. To most kinds of food for horses, the addition of one or two ounces of salt is necessary.

In the *Agricultural Gazette* for November 25, 1865, the following instructive tables are given:—

STABLE FEEDING DURING AUTUMN.

No.	Name and Address of Authorities.	Hay.	Oats.	Beans.	Clover, &c.	Weekly Cost.
		lb.	lb.	lb.		s. d.
1	W. Gater, Botley ...	168	63*	32*	...	12 0
2	W. C. Spooner ...	112	84	24	...	11 0
3	T. Aitken, Spalding .	...	37½	...	ad lib.	7 6?
4	,, ,, ...	...	37½	35	ad lib.	10 0?
5	T. P. Dods, Hexham.	...	105	...	ad lib.	10 6?
6	,, ,,	ad lib.	105	...	...	10 6?
7	A. Ruston, I. of Ely.	ad lib. ½	84	10	Straw ad lib. ½	9 0
8	A. Simpson, Beauly...	168	70	14	Bran. ⅓ bush. 24 lb.	10 0
9	H. J. Wilson, Mansfield	...	52½	...	Straw. ad lib.	7 3?
10	,, ,,	42	87½	...	ad lib.	9 0

In this table the asterisk (*) means that the grain is crushed or ground.

STABLE FEEDING DURING WINTER.

No.	Name and Address.	Hay.	Oats.	Beans.	Roots.	Sundries.	Straw.	Weekly Cost.
		lb.	lb.	lb.		lb.	lb.	s. d.
1	Professor Low—Elements of Agriculture	56*	56*	...	Potatoes 56†	...	56*	6 6
2	H. Stephens—Book of the Farm ...	112	35	...	Turnips 112	...	...	6 0
3	J. Gibson, Woolmet—H. Soc. 1850 ...	...	84	...	217†	Potatoes 217†	112	9 0
4	— Binnie, Seaton ...	...	70*	28*	243†	Barley 42†	ad lib.	11 6
5	— Thomson, Hangingside	...	84	14	336	14	ad lib.	9 6
6	W. C. Spooner, Ag. Soc. Journ., vol. ix.	...	63	...	42	...	196	4 9
7	T. Aitken, Spalding, Lincolnshire ...	ad lib. (⅔)	37	35	...	...	ad lib. (⅓)	9 0
8	G. W. Baker, Woburn, Bedfordshire.	...	60*	20*	...	...	...	9 8
9	R. Baker, Writtle, Essex	70	42	...	...	...	140	5 0
10	J. Coleman, Cirencester	...	84	16	...	...	ad lib.	7 3
11	T. P. Dods, Hexham	...	95	...	56	...	ad lib.	8 0
12	J. Cobban, Whitfield	84*	60*	...	...	Linseed 3½	ad lib.*	7 3
13	S. Druce, jun., Ensham	112	52	...	Swedes 70	...	2 bu.*	7 0
14	C. Howard, Biddenham	ad lib. (⅔)	52	17	84	...	ad lib. ⅓*	8 6?
15	J. J. Mechi, Tiptree.	49*	70*	...	M. Wurzel 210	...	ad lib.*	7 6
16	W. J. Pope, Bridport	2*	84	...	...	...	ad lib.	9 0?
17	S. Rich, Didmarton, Gloucestershire ...	168	63	...	...	Grains 2 bush.	ad lib.	10 8
18	H. E. Sadler, Lavant, Sussex	140	84	...	...	...	...	9 9
19	J. Morton, Whitfield Farm	...	126	...	Carrots 350	...	ad lib.	10 9
20	E. H. Sandford, Dover	56	42	...	...	Bran 12	ad lib.	5 6
21	A. Simpson, Beauly, N.B.	...	49	7	105	Tail Corn 21	ad lib.*	5 6
22	H. J. Wilson, Mansfield	42	52½	...	...	Bran 21	ad lib.	6 6?
23	F. Sowerby, Aylesby, North Lincolnshire	112	28	Cut Oat Sheaf.		...	ad lib.*	8 0?

Where an asterisk (*) is attached to any item, it is to be understood that the corn has been bruised or ground, or the hay or straw has been cut into chaff. Where a dagger (†) is appended, the article so marked has been boiled or steamed. A mark of interrogation (?) indicates that the result so marked is uncertain, owing to some indefiniteness in the account given.

On feeding horses with pulped roots, Mr. Slater, of Weston Colville, Cambridgeshire, says :—

I give all my cart horses a bushel per day of pulped mangel, mixed with straw and corn-chaff. I begin in September, and continue using them all winter and until late in the summer, nearly, if not quite, all the year round, beginning, however, with smaller quantities, about a peck, and then half a bushel, the first week or two, as too many of the young-growing mangel would not suit the stock. I believe pulped mangels, with chaff, are the best, cheapest, and most healthy food horses can eat. I always find my horses miss them when I have none, late in the summer. I give them fresh ground every day. Young store beasts, colts, &c., do well with them.

PART IV.

MEAT, MILK, AND BUTTER.

SECTION I.

MEAT.

No one ought to feel a greater interest in the subject of meat in all its branches than the stock feeder. Just in proportion as this kind of food is agreeable to the taste, easily digestible, and rich in nutriment, will the demand for it increase. The quality of meat is, in fact, a primary consideration with the producer of that article; and he whose beef and mutton are the most tender and the best flavored will make the most profit.

Quality of Meat.—The flesh of herbivorous animals is composed of muscular and adipose (fatty) tissues. The muscles consist of bundles of elastic fibres *(fibrine)*, enclosed in an albuminous tissue formed of little vessels, termed cells, and intimately commingled with water, and a mixture of albuminous, fatty, and saline matters. The leanest flesh (muscles) contains fat, but the latter accumulates in certain parts of the body—often to such an extent as to seriously interfere with the functions of life. The red color of flesh is due to a rather large proportion of blood, which it contains in minute vessels; and the slight acidity of its juice is owing to the presence of *inosinic* acid, and probably of several other acids. The agreeable odour of meat, when it is subjected to the process of cooking, is developed from a complex substance termed *osmazome.**

* From two Greek words, signifying odour and soup.

This constituent varies in nature and quantity in the different animals—hence the variety in flavor and odour of their flesh—and its amount increases with the age of the animal. The albumen of the muscles, and their fatty and saline constituents, are digestible; but it is generally believed that the elastic fibres, and the horny cellular tissue which binds them into bundles, are not assimilable. It is more certain that the crystalline substances found in flesh, such as, for example, *kreatine*, are incapable of ministering to the nutrition of animals.

The composition of flesh varies very much—that of a very obese pig containing more than half its weight of fat, whilst in some specimens of "jerked beef," imported from Monte Video, scarcely 5 per cent. of that substance was found. The flesh of a fat ox has on an average the following composition:—

	Per cent.
Water	45
Fatty substances	35
Lean flesh, or muscle	15
Mineral matters	5
Total	100

I have examined for Dr. Morgan several specimens of the corned beef recently prepared in South America, by "Morgan's process." The following were the average results of three analyses:—

	Per cent.
Water	40
Fatty matters	21
Lean, or muscular flesh	27
Mineral matters (chiefly common salt) ...	12
Total	100

It may not here be out of place to direct attention to the composition of a kind of animal food extensively purchased by the poorer classes, and known under the term of slink veal. It is the flesh of calves that are killed on the first day of their existence, and also, I have reason to believe, that of very immature animals—of calves that have never breathed. The flesh is of a

very loose texture naturally, and is still further puffed out by air, which is usually supplied from the lungs of the operator. This kind of meat, though regarded as a delicacy by some people, is not held in much estimation, otherwise its price would be higher than it is. It is at present sold at about 4d. or 5d. per pound, sometimes even at a lower rate. Apart from the disgusting process of "blowing" veal, so generally adopted, the use of this food is extremely objectionable, owing to its great tendency to produce diarrhœa. To the truth of this assertion every physician who has studied the subject of dietetics can testify. I have analysed a specimen of it (purchased from a person who admitted that it was part of a calf a day old), and obtained the following results:—

100 parts contain—

	Per cent.
Water	72·25
Fat	6·17
Lean flesh	18·46
Mineral matter	3·12
Total	100·00

I believe that a large portion of the lean flesh is indigestible; and altogether I may safely say of this kind of meat that it is, especially during the prevalence of cholera, an unsafe article of diet. Of course these observations do not apply to *fed* veal, the only kind which respectable butchers, as a rule, offer for sale.

Young meat is richer in soluble albumen and poorer in fibrine and fat than the matured flesh of the same animal. The flesh of the goat contains *hircic* acid, which renders it almost uneatable, but this substance is either altogether absent from, or present but in minute proportion in, the well-flavored meat of the kid. The flesh of game contains abundance of osmazome, a substance which is somewhat deficient in that of the domestic fowl.

Owing to the marked individuality which man exhibits in the selection of his food, and to the intimate relationship sub-

sisting between food and the organism it nourishes, it is impossible to arrange the alimental substances in the strict order of their nutritive values. You can bring a horse to the water, but you cannot compel him to drink it; you can swallow any kind of food you please, but you cannot force your stomach to digest it. It is, therefore, vain to tell a man that a certain kind of food is shown by chemical analysis to be nutritious, when his stomach tells him unmistakeably that it is poisonous, and refuses to digest it. In the matter of dietetics Nature is a safer guide than the chemist. Many substances, when viewed only in the light shed upon them by chemical analysis, appear to be rich in the elements of nutrition, yet when they are introduced into the stomachs of certain individuals, they disarrange the digestive organs, and sometimes cause the whole system to go out of order. Every day we see exemplified the truth of the proverb, that "one man's meat is another man's poison." There are persons who relish and readily digest fat pork, and yet they cannot eat a single egg with impunity; others enjoy and easily assimilate eggs, but their stomachs cannot tolerate a particle of fat bacon.

It is not merely the composition of an aliment and its adaptability to the organism which determine its nutritive value—its digestibility and flavor are points which affect it. There are few people in these countries who are disposed to quarrel with beef; but no one would prefer the leg of an elderly milch cow to the sirloin of a well-fed three-year-old bullock: yet if our selection were to be determined by the analysis of the two kinds of beef, we would be just as likely to prefer the one as the other. No doubt the relative tenderness of meats may be ascertained by experiments conducted *outside* the body; but tenderness is not in every case synonymous with easy digestibility. Veal contains more soluble albumen, and is, consequently, far more tender than beef; yet, as every one knows, it is less digestible. It is curious that maturity renders the flesh of some animals more digestible, and that of others less digestible. Flavor has something to do with these differences.

Beef is richer than veal in the agreeably flavorous osmazome, and the flesh of the kid is destitute of the disagreeable odour of the fully-developed goat. The superiority of wild-fowl over the domesticated birds is solely owing to the finer flavor of their flesh.

The habits of animals, and the nature of their food, affect the quality of their flesh. Exercise increases the amount of osmazome, and consequently renders the meat more savory. The mutton of Wicklow, Wales, and other mountainous regions is remarkably sweet, because the animals that furnish it are almost as nimble as goats, and skip from crag to crag in quest of their food. The fatty mutton, with pale muscle, which is so abundant in our markets, is furnished by very young animals forced prematurely into full development. Those animals have abundance of food placed within easy reach; their muscular activity is next to *nil*, and the result is, that their flesh contains less than its natural proportion of savory ingredients. It is the same with all other animals. The flesh of the tame rabbit is very insipid, whilst that of the wild variety is well flavored. Wild fowls cooped up, and rapidly fattened, lose their characteristic flavor; and when the domesticated birds become wild their flesh becomes less fatty, and acquires all the peculiarities of game. Ducks, whether wild or tame, ordinarily yield goodly meat; but the flesh of some of those that feed on fish smacks strongly of cod-liver oil. Birds which subsist partly on aromatic berries assimilate the odour as well as the nutriment of their food. The flesh of grouse has very commonly a slight flavor of heather. Foster states that in Tahiti pigs are fed upon fruit, which renders their fat very bland and their flesh like veal. Animals subjected to certain kinds of mutilation fatten more rapidly than they do in their natural state. Capons increase in weight more rapidly than cocks, poulards than hens, bullocks than bulls, and cows deprived of their ovaries than perfect cows. Why it is that the flesh of mutilated animals should be fatter and more tender than that of whole animals, we know not; we only know that

such is the fact. The hunting of animals renders their flesh more tender; the cause assigned is, that the great exertion of the muscles liquefies their fibrine, which is the toughest of their constituents. The meat of animals brought very early to maturity is seldom so valuable as the naturally developed article. Lawes and Gilbert state that portions of a sheep that had been fattened upon *steeped* barley and mangels, and which gave a very rapid increase, yielded several per cent. less of cooked meat, and lost more, both in dripping and by the evaporation of water, than the corresponding portions of a sheep which had been fed upon *dry* barley and mangels, and which gave only about half the amount of gross increase within the same period of time:

Although the digestibility and flavor of meat (and of every other kind of food) affect its nutritive value, these points are in general of far less importance than its composition. Potatoes are not so nutritious as peas, because they contain a smaller amount of fat and flesh-formers; but they are more digestible. Fish contains less solid matter than flesh, and is less nutritious, yet a cut of turbot will be, in general, more easily digested than an equal weight of old beef. The fact is, that digestibility and flavor are only of great importance to dyspeptic persons. In the healthy digestive organs a pound weight of (dry) food of inferior flavor and slow digestibility will be just as useful as the same weight of well-flavored and easily assimilable aliment, provided all other conditions be alike. If the food be eaten with a relish, and tolerated by the stomach, its digestibility will not, except in extreme cases, affect in a very sensible degree its nutritiveness.

Were one question in animal nutrition satisfactorily answered, it would then be comparatively easy to arrange aliments in the order of their nutritive value. That question is—What are the proper relative proportions of the fat-forming and flesh-forming constituents of our food? It is constantly urged, that the food of the Irish peasantry contains an excess of the fat-forming materials in relation to the muscle-forming substances; and

the remedy suggested is, that their staple article of food—potatoes—should be supplemented with flesh, peas, and such like substances, in which, it is supposed, the elements of nutrition are more fairly balanced. In potatoes, the proportion of fat-formers (calculated as fat) is about five times as much as that of the flesh-formers; but these principles exist in the same relative proportions in the fat bacon with which the potato-eater loves to supplement his bulky food. In bread we find the proportion of fat-formers to be only $2\frac{1}{2}$ times as much as that of the flesh-formers, whilst, according to Lawes and Gilbert, the edible portion of the carcass of a fat sheep contains $6\frac{1}{2}$ times as much fat as nitrogenous (flesh-forming) compounds. It is evident, then, that meat such as, for example, the beef recently imported from Monte Video, from which the fatty elements of nutrition are almost completely absent, cannot be a suitable adjunct to a farinaceous food.

There is evidence to prove that in the animal food consumed by the population of these countries, the proportion of fatty to nitrogenous matters is greater than in the seeds of cereal and leguminous plants, and but little less than in potatoes. "It would appear to be unquestionable," say Lawes and Gilbert, "therefore, that the influence of our staple *animal foods*, to supplement our otherwise mainly farinaceous diet, is, on the large scale, to *reduce*, and *not to increase*, the relation of the *assumed* flesh-forming material to the more peculiarly respiratory and fat-forming capacity, so to speak, of the food consumed." It must be remembered, too, that the fat *formers* are ready *formed* in animal food, whereas they exist chiefly in the form of starch, gum, sugar, and such-like substances in vegetables. According to theory, $2\frac{1}{2}$ parts of starch are equivalent to, *i.e.*, convertible into, 1 part of fat; but it is not certain whether the force which effects this change is derivable from the $2\frac{1}{2}$ parts of starch, or from the destruction of tissue, or of another portion of food. If there be a tax on the system in order to convert starch into fat, it is evident that $2\frac{1}{2}$ parts of

starch, though convertible into, are not equivalent in nutritive value to one part of fat.

It is quite certain that millions of healthy, vigorous men have subsisted for years exclusively on potatoes; but it is no less clear that a diet of meat and potatoes enables the laborer to work harder and longer than if his food were composed solely of potatoes. But we have seen that the relation between the flesh-forming and fat-forming elements is nearly the same in both potatoes and meat; so that the superiority of a meat or mixed diet cannot be chiefly owing, contrary to the generally received opinion, to a greater abundance of flesh-forming materials. As the proportion of flesh-formers to fat-formers is so much greater in wheaten or oaten bread than in potatoes, and as peas and other vegetables rich in nitrogenous compounds are practically found to be an excellent supplement to potatoes, it is probable that the latter may be somewhat relatively deficient in flesh-forming capacity. It is, however, in all probability the great bulk of a potato diet, and its total want of ready formed fat, that render the addition to it of animal food so very desirable. The concentrated state in which the ingredients of flesh exist, the intimate way in which they are intermixed, their agreeable flavor, and their (in general) ready and almost complete digestibility, appear to be the principal points in which a meat diet excels a vegetable regimen. There may be others, which, though less evident, are, perhaps, of equal importance. At all events, the general experience of mankind testifies to the superiority of a mixed animal and vegetable diet over a purely vegetable one.

Is very Fat Meat wholesome?—The enormous and rapidly increasing demand for meat which characterises the food markets of these days, has reacted in a remarkable manner upon the nature of the animals that supply it. Formerly the animals that furnished pork, mutton, and beef, were allowed to attain the age of three years old and upwards before they were considered to be "ripe" for the butcher; but now sheep and pigs are perfectly *matured* at the early age of one year, and

two-year-old oxen furnish a large quota of the "roast beef of old England." The so-called improvement of stock is simply the forcing of them into an unnatural degree of fatness at an early age; and this end is attained by dexterous selection and crossing of breeds, by avoidance of cold, by diminishing as much as possible their muscular activity, and lastly, and chiefly, by over-feeding them with concentrated aliments.

Every one knows that a man so obese as to be unable to walk cannot be in a healthy state; yet many feeders of stock look upon the monstrously fat bulls and cows of cattle show prize celebrity as normal types of the bovine tribe. It requires but little argument to refute so fallacious a notion. No doubt it is desirable to encourage the breeding of those varieties of animals which exhibit the greatest disposition to fatten, and to arrive early at maturity; but the forcing of individual animals into an unnatural state of obesity, except for purely experimental purposes, is a practice which cannot be too strongly deprecated. If breeders contented themselves with handing over to the butcher their huge living blocks of fat, the matter would not perhaps be very serious; but, unfortunately, it is too often the practice to turn them to account as sires and dams. Were I a judge at a cattle show, I certainly should disqualify every extremely fat animal entered for competition amongst the breeding stock. Unless parents are healthy and vigorous, their progeny are almost certain to be unhealthy and weakly; and it is inconceivable that an extremely obese bull and an unnaturally fat cow could be the progenitors of healthy offspring. We should by all means improve our live stock; but we should be careful not to overdo the thing. If we must have gaily-decked ponderous bulls and cows at our fat cattle exhibitions, let us condemn to speedy immolation those unhappy victims to a most absurd fashion; but in the name of common sense let us leave the perpetuation of the species to individuals in a normal state, whose muscles are not replaced by fat, whose hearts are not hypertrophied, and whose lungs are capable of effectively performing the function of respiration.

Mr. Gant, in a small volume* devoted wholly to the subject, describes the serious functional and structural disarrangements which over-feeding produces in stock. He found the heart of a one-year old Southdown wether, fattened according to the *high-pressure system*, to be little more than a mass of fat. In several other young, but so-called "matured" sheep, he found more or less fatty degeneration of the heart, and extensively spread disease of the liver and of the lungs. A four-year old Devon heifer, exhibited by the late Prince Consort at a Smithfield show, was found to be in a highly diseased state. It was slaughtered, and of course its flesh sold at a high price as "prize beef," but its internal organs came into Mr. Gant's possession. The substance of both ventricles of the heart had undergone all but complete conversion into fat; one of its muscles was broken up, and many of the fibres of the others were ruptured. In another animal the muscular fibres of the heart had given way to so great an extent that if the thin lining membrane (*endocardium*) had burst, death would have instantly ensued. The slightest exertion was likely to cause this catastrophe; but, fortunately enough in this case, the animal was not capable of exertion, for though under three years of age, it weighed upwards of 200 stones: this animal had received for some time before its exhibition, the liberal allowance of 21 lbs. of oil-cake (besides other food) per diem. "A pen of three pigs," says Mr. Gant, "belonging to his Royal Highness the Prince Consort, happened to be placed in a favorable light for observation, and I particularly noticed their condition. They lay helpless on their sides, with their noses propped up against each other's backs, as if endeavouring to breathe more easily, but their respiration was loud, suffocating, and at long intervals. Then you heard a short catching snore, which shook the whole body of the animal, and passed with the motion of a wave over its fat surface,

* "A New Inquiry, fully illustrated by coloured engravings of the heart, lungs, &c., of the Diseased Prize Cattle lately exhibited at the Smithfield Cattle Club, 1857." By Frederick James Gant, M.R.C.S. London, 1858.

which, moreover, felt cold. I thought how much the heart under such circumstances must be laboring to propel the blood through the lungs and throughout the body. The gold medal pigs of Mr. Moreland were in a similar condition, if anything, worse; for they snored and gasped for breath, their mouths being opened, as well as their nostrils dilated, at each inspiration. From a pig we only expect a grunt, but not a snore. These animals, only twelve months and ten days old, were marked '*improved* Chilton breed.' They, with their fellows just mentioned, of eleven months and twenty-three days, had early come to grief. Three pigs of the black breed were in a similar state, at seven months three weeks and five days, yet such animals 'the judges highly commended.'"

Dr. Brinton denies the accuracy of several of Mr. Gant's statements relative to the structural changes in the muscles of obese animals; but I do not think that he has succeeded in disproving the principal assertions made by the latter.

There is conclusive evidence to prove that one of the effects of the present mode of fattening beasts is disease of the internal organs of the animals; but it is by no means certain that the flesh of those diseased animals is as unwholesome food as some writers assert it to be. The flesh of an over-fattened animal differs from that of a lean, or moderately fat one, in containing an exceedingly high proportion of fat; but it has not been proved that the fat of prize animals differs from the fat of lean kine, or that it is less wholesome or nutritious. Be the flesh of those exceedingly fat animals unwholesome or not, there are thousands, ay, millions of persons, to whom its greasy quality renders it peculiarly acceptable; and as for those who dislike fat—they do not usually invest their money in the flesh of prize sheep or oxen. At the same time, it must not be understood that all, or even a large proportion of fully matured stock is in a diseased state; though in most of them the vital and muscular powers are undoubtedly exceedingly low.

There is no doubt but that sheep and oxen, from three to

five years old, moderately fat, and fairly exercising their locomotive powers, furnish the most savory, and, perhaps, the most nutritious meat: but if such were the only kind of meat in demand, it may be fairly doubted that the supply would be equal to it. The produce of meat in these countries has been rapidly increasing for many years past; and the weight of meat annually supplied from a given area of land is now from 80 to 100 per cent. greater than it furnished thirty or forty years ago. It is chiefly by means of the so-called forcing system that the produce of meat has been so considerably increased. If this system were abandoned, the production would be greatly diminished, and the consequently high price of the article would place it beyond the reach of the masses of the population. Besides, it has not been proved that the flesh of the animals brought early to maturity is much inferior, except somewhat in flavor, to the meat of three-year-old beasts. There is, no doubt, plenty of unwholesome meat offered for sale, but it is that of animals which were affected by diseases as likely to attack the young as the old. On the whole, then, we may say of the improved system of fattening stock, that it produces a maximum amount of meat on a given area of land; that the meat so produced is, except in rare cases, perfectly wholesome; that it is capable of supplying the ingredient—fat—which is almost wholly absent from a vegetable diet; and, finally, that it places animal food within the reach of the working classes.

Diseased Meat.—The losses occasioned to stockowners by the diseases of live stock are far greater than is generally supposed. It has been calculated that in the six years ending 1860, the value of the horned stock lost by disease amounted to £25,934,650. Pleuro-pneumonia was the chief cause of these losses. Exclusive of the enormous losses occasioned by the ravages of the rinderpest, the annual loss by disease in live stock in these countries for some years past cannot be much under £6,000,000 sterling.

Whether it is owing to the somewhat abnormal condition under which the domesticated animals are placed, or to causes

which operate upon them when in a state of nature, it is certain that they are remarkably prone to disease. It is extremely difficult to get a horse six years old that is not a roarer or a whistler, or "weak on his pins," or in some way or other unsound. Oxen, sheep, and pigs have almost as many maladies afflicting them as human flesh is heir to, notwithstanding the short period of life which they are permitted to enjoy.

It is a very serious question whether or not the flesh of animals that have been killed while they are in a diseased condition is injurious to health. The opinions on this point are conflicting, but the majority of medical men believe that the flesh of diseased animals is not wholesome. There are certain maladies which obviously render meat unsaleable, by causing a sensible alteration in its quality. For example, blackleg in cattle and measles in the porcine tribe render the flesh of these animals, as a general rule, unmarketable, or nearly so. But there are very serious diseases—often proving rapidly fatal—which, whilst seriously affecting certain internal organs, do not palpably deteriorate the quality of the flesh. In such cases are we to rely upon the evidence of our mere senses in judging of the wholesomeness of the meat? If we find beef possessing a good color and odour, and firm to the touch, and *appearing* to be in every respect healthy flesh, are we under such circumstances to take it for granted that it must be healthy? This is a very important question, involving as it does the interests of both the producers and consumers of animal food. If the flesh of all diseased animals be unwholesome, a very large number of oxen now sold whilst laboring under pleuro-pneumonia should not be sent into the market. This, of course, would be a heavy loss to the stockowner, but a still heavier one to the meat consumer; because, if there were fewer animals for sale, the price of meat would ascend, in obedience to the law of supply and demand. The whole question is, then, well worthy of being considered in the most careful, unbiassed, and scientific manner; for at present it is in a state which is the reverse of being satisfactory.

A large proportion of the animals conducted to the shambles is in a diseased condition. Professor Gamgee estimates it at no less than one-fifth. Dr. Letheby, food analyst to the Corporation of London, condemns weekly about 2,000 pounds weight of flesh ; but as his jurisdiction is limited to the "City," which contains a population of only about 114,000, the 2,000 pounds of diseased meat are probably only about 1-30th of the quantity exposed for sale within the whole area of the metropolis. Making an estimate of the most moderate kind, we may assume that 30,000 pounds weight of bad meat are weekly offered for sale in London—*three million pounds weight annually.*

Many persons have been affected with dysentery and choleraic symptoms after partaking of butcher's meat of apparently the most healthy kind. The meat has often been subjected to minute chemical and microscopical examination, but no poison has been discovered. But these cases are becoming so frequent that they are exciting uneasiness, and demand an exhaustive investigation. The unskilful persons who officiate in the capacity of "clerks of the market" and inspectors of meat can only judge of the quality of flesh that is obviously inferior to the eye, nose, or touch ; but are there not cases where the flesh may appear to be good, and yet contain some subtle malign principle? It is an ascertained fact that young or "slink" veal very frequently gives rise to diarrhœa, more especially when that disease is epidemic. Dr. Parkes, in his celebrated work on Hygiene, page 162 (second edition), states that "the flesh of the pig sometimes produced diarrhœa—a fact I have had occasion to notice in a regiment in India, and which has often been noticed by others. The flesh is, probably, affected by the unwholesome garbage on which the pig feeds." Menschell states that 44 persons were afflicted with anthrax after eating the flesh of oxen affected with carbuncular fever. Dr. Kesteren, in the *Medical Times* for March, 1864, mentions a case where twelve persons were affected with choleraic symptoms after the use of pork not obviously diseased. At Newtownards, county of Down, several

persons died after eating veal in which no poisonous matter of any kind could be detected. One instance has come under my own notice where a man, two dogs, and a pig died after eating the flesh of an animal killed whilst suffering from splenic apoplexy. Several butchers have lost their lives in consequence of the blood of diseased animals being allowed to come in contact with abrasions or recently received wounds on their arms. The flesh of over-driven animals is stated by Professor Gamgee to produce a most serious skin disease, although the meat appeared to be perfectly healthy. The Belgian Academy of Medicine has decided that the flesh of animals suffering from carbuncular fever is unwholesome, and its sale in that country is prohibited.

Many persons have died in Germany and a few in England from a disease produced by eating pork containing a small internal parasite termed *trichina spiralis*. I have recently met with a case of *trichiniasis* in the human subject. The body of the unfortunate person—who had been an inmate of the South Dublin Union Workhouse—was found to contain thousands of the trichinæ. In Iceland a large proportion of the population suffers from a parasitic disease traceable to the use of the flesh of sheep and cattle in which flukes abound.

Pleuro-pneumonia is in this country the disease which most frequently affects the ox. It is probable that about 5 per cent. of these animals sold in Dublin are more or less affected by this malady. There are two forms of pleuro-pneumonia—the sporadic, or indigenous, and the foreign, or contagious. It is the latter form which has become the scourge of the ox tribe in this country, though unknown here until the year 1841, when it appeared as an epizoötic, and carried off vast numbers of animals.

The contagious pleuro-pneumonia is an extremely severe inflammatory disease, and is produced—not in the same way that common pleuro-pneumonia is, by exposure to excessive cold, &c.—but by a blood poison received from an infected animal. In the congestive stage of the disease there is no

structural alteration in the organs of the animal, and if well bled its flesh might (probably) be safely eaten; but when a large portion of the lungs becomes solidified, and rendered incapable of purifying the blood, is it not doubtful, to say the least, that the blood or flesh is perfectly wholesome? The blood, during the life of the animal, is in a state of fermentation; there is extreme fever, and the animal presents all the characteristic symptoms of acute disease. On being killed, the flesh, if the disease be of a fortnight's duration, will usually be extremely dark, but in a less advanced stage of the malady the flesh will generally present a healthy appearance. Is it really so? That is the question which science has to determine. Going upon a broad principle, I can hardly conceive that so serious a disease as pleuro-pneumonia does not injuriously affect the quality of the flesh. It is no argument to say that thousands consume such flesh, and yet enjoy good health. Millions of people drink water and breathe air that are extremely impure, and yet they do not speedily die. It is one thing to be poisonous, another to be unwholesome. The flesh of animals killed whilst suffering from lung distemper is not directly poisonous, but who can prove that it is not, like bad water, unwholesome?

As analyst to the city of Dublin, I am almost daily called upon to inspect meat suspected to be unwholesome; and I have always condemned as being unfit for human food:—

1. Animals slaughtered at the time of bringing forth their young.

2. Oxen affected with pleuro-pneumonia, when pus is present in the lungs, or the flesh obviously affected; animals suffering from murrain, black-quarter, and the different forms of anthrax.

3. Animals in an anæmic, or wasted condition.

4. Meat in a state of putrefaction.

During the present year about 20,000 pounds weight of meat have been seized and condemned in the city of Dublin.

SECTION II.

MILK.

MILK is a peculiar fluid secreted by the females of all animals belonging to the class *Mammalia;* and, being designed for the nourishment of their offspring, contains all the constituents which enter into the composition of the animal body.

The milk of different animals varies very much in color, taste, and nutritive value. That of the cow is a little heavier than water—its specific gravity being, on the average, about 1·030, waterbeing 1·000. It is composed of three constituents—namely, butter, curd, and whey—each of which is also composed of a number of substances. These three constituents are of unequal weight, or specific gravity, and their separation is the chief process carried on in the dairy. The butter is the lightest and the curd is the heaviest constituent.

The following table represents the composition of the milk of different animals :—

COMPOSITION OF THE MILK OF DIFFERENT ANIMALS.

1,000 PARTS CONTAIN—

	Specific Gravity, or Density.	Water.	Solid Ingre-dients.	Cheesy Matter.	Sugar.	Butter.	Mineral Matter.
Woman ...	1032·67	889·08	110·92	39·30	43·68	26·66	1·30
Cow	1030	864·20	135.80	48·80	47·70	31·30	6·00
Goat	1033·53	844·90	155·10	35·14	36·91	56·87	6·18
Ewe	1040·98	832·32	167·68	69·78	39·43	51·31	7·16
Mare	1033·74	904·30	95·70	33·35	32·76	24·36	5·23
Ass	1034·57	890·12	109·88	35·65	50·46	18·53	5·24
Bitch	1041·62	772·08	227·92	116·88	15·29	87·95	7·80

Milk examined through a microscope is a colorless fluid, containing a large number of little vesicles, or bags, filled with butter—a mixture of oily and fatty matters. When the milk stands for some time, the globules, being lighter than the other constituents, ascend to the top, and, mixed with a certain pro-

portion of milk, are removed as cream. The curd is termed in scientific parlance *casein*, and is in fresh milk in a state of solution—that is to say, is dissolved in milk in the same way that we dissolve sugar in water. When milk becomes sour, either naturally or by the addition of rennet, it can no longer hold casein in solution, and the curd consequently separates. Casein is the substance which forms the basis of cheese. The substance that remains after the removal of the butter and cheese is called *serum*, or whey, and is composed of a sweetish substance termed *sugar of milk*, and certain saline bodies, termed the ash, dissolved in water.

The butter and the sugar of milk are employed in the animal economy in the production of fat, and are what have been styled by physiologists *heat-producers* and *fat-formers*. The casein resembles the gluten of wheat in composition; it belongs to the class of food substances termed *flesh-formers*. The ash, or mineral part of the milk, is chiefly employed in forming the bones of the young animals it is destined to nourish.

The quality of milk is influenced by the quantity and quality of the food given to the animal. The milk of cows fed on distillery wash, turnip, and mangel tops, coarse herbage, and other kinds of inferior food, is always of inferior quality. Hence it is of great importance that dairy stock be kept in good old pastures in summer, and fed on Swedish turnips, mangel-wurzel, and oil-cake during winter. It is true economy to supply dairy cows with abundance of nutritious food; and it should be constantly borne in mind that the milk from two well-fed cows will give more butter than can be obtained from the produce of three badly-fed animals.

The butter is the constituent of milk which is most affected by the nature and amount of the animal's food; and butter is precisely the article which is of the greatest importance to the Irish dairy farmer, as the quantity of cheese prepared in this country is inconsiderable. When, therefore, it is found that a cow pastured on inferior land, or badly fed in the byre, yields

a large supply of milk of a high specific quantity (which, however, is rarely the case), it must not be concluded that the result is satisfactory; for if such milk be tested by the lactometer it will certainly be found wanting in butter. The average composition of English milk, according to Way, is :—

Water	87.02
Butter	3.23
Casein	4.48
Sugar of milk	4.67
Ash	0.60
	100.00

In several analyses of milk published by Professor Voelcker, the highest proportion of butter is stated to be 7.62. In that of cows kept on poor and over-stocked pastures less than 2 per cent. was found. I have examined in my capacity of Food Analyst to the City of Dublin several hundred samples of milk, in not one of which have I found the proportion of butter to amount to more than 5.6 per cent. In no sample did I find a higher per-centage of solid matter than 13.15, or (when pure) lower than 12.08. The quality of the food of the milch cow exercises a great influence on the quality and yield of her milk. Aliments rich in fat and sugar favor the production of butter, and augment the supply of milk. Locust-beans, malt, and molasses are good milk-producing foods; but the chief condition in the production of milk rich in butter is simply that the animals which yield it must be fed with abundance of nutritious food. Nor must it be supposed that the richness of milk is due to the smallness of the yield, for whenever the quality of the secretion is inferior, it is almost certain to be deficient in quantity. Those cows which give the richest milk, generally yield the largest quantity.

Yield of Milk.—According to Boussingault, a cow daily yields on the average 10.4 parts of milk per 1,000 parts of her weight. Morton, in his "Cyclopædia of Agriculture," p. 621, states that Mr. Young, a Scotch dairy keeper, obtained 680

gallons per cow per annum. Voelcker found that some common dairy stock gave each of them fifty-two pints of milk per diem, whilst three pedigree cows yielded respectively forty-nine pints.

Professor Wilson gives the following information on this point:—

Our principal dairy breeds are the Ayrshire, the Channel Islands, the Short-horn, the Suffolk, and the Kerry. Some published returns of two dairies of Ayrshire cows give the annual milk produce per cow at 650 and 632 gallons respectively. Three returns of dairies, consisting wholly of Short-horns, show a produce of 540 gallons, 630 gallons, and 765 gallons respectively, or an average of 625 gallons per annum for each cow. In two dairies, where half-bred Short-horns were kept, the yield was 810 and 866 gallons respectively for each cow. In four dairies in Ireland, where pure Kerrys and crosses with Short-horns and Ayrshires were kept, the annual produce per cow was returned at 500 gallons, 600 gallons, 675 gallons, and 740 gallons respectively; or an average, on the four dairies, of 630 gallons per annum for each cow. A dairy of "pure Kerrys" gave an average of 488 gallons per cow, and another of the larger Irish breed gave an average of 583 gallons per head per annum. In the great London dairies, now well-nigh extinguished by the ravages of the cattle disease, these returns are greatly exceeded. The cows kept are large framed Short-horns and Yorkshire crosses, which, by good feeding, bring the returns to nearly 1,000 gallons per annum for each cow kept. The custom in these establishments is to dispose of a cow directly her milk falls below two gallons a-day, and buy another in her place.

The following milk return of one of our best managed dairy farms (Frocester Court) shows the relative produce of cows in the successive years of their milking. The first lot was bought in at two-years old; all the others at three years:—

No. of Cows.	Year of Milk.	Produce per head.
8	1st	317 gals.
15	1st	472 ,,
14	2nd	353 ,,
15	3rd	616 ,,
20	4th	665 ,,
18	5th	635 ,,
9	6th	708 ,,
15	Old	651 ,,

The maximum reliable milk produce that we have recorded was that of a single cow belonging to the keeper of the gaol at Lewes, the details of

which were authenticated by the Board of Agriculture. In eight consecutive years she gave 9,720 gallons, or at the rate of more than 1,210 gallons per annum. In one year she milked 328 days, and gave 1,230 gallons, which yielded 540 lbs. of butter, or at the rate of 1 lb. of butter to 22¾ lb. of milk. In the early part of the present year (1866) a return was published of the produce of a cow in a Vermont (U.S.) dairy, which was stated to have given, in the previous year, a butter yield of 504 lbs., at the rate of 1 lb. of butter to 20 lbs. of milk.*

Preserved Milk.—Various plans have been proposed to render milk more portable, and to preserve it sweet for days and even months. Mr. Borden of Connecticut, United States, prepares a concentrated milk by boiling the fluid down in vacuo, at a temperature under 140° Fahrenheit, mixing the resulting solid with sugar, and rapidly placing the compound in tins, which are then hermetically sealed. It is said that solidified milk prepared by this process remains sweet for many months. In France, solidified and concentrated milk are largely prepared; and it is certain that London and other large towns will yet be supplied with milk rendered portable and more stable, by the removal of a large proportion of its water. In many parts of Ireland pure milk could be bought at from 7d. to 8d. per gallon. I do not despair to see factories established in such places for the manufacture of preserved milk as a substitute for the dear and impure fluid sold under the name of milk in London and other large cities. It is stated that solidified milk prepared in Switzerland is now sold in London.

SECTION III.

BUTTER.

History of Butter.—The very general use of butter as an article of food is demonstrated by the familiar saying—"We should not quarrel with our bread and butter"; yet this article,

* Professor John Wilson's Report of the Agricultural Exhibition, Aarhuus, 1867.

now so commonly used throughout the greater part of Europe, was either unknown or but imperfectly known to the ancients. In the English translation of the Holy Scriptures the word butter does certainly frequently occur; but the Hebrew original is *chamea*, which, according to the most eminent Biblical critics, signifies cream, or thick, sour milk. In the 20th chapter of Job the following passage occurs:—"He shall not see the rivers, the floods, the brooks of honey and butter." Now, we can conceive streams of thin cream, but we cannot imagine a river of butter. The oldest mention of butter is found in the works of Herodotus. In the description of the Scythians given by this ancient author, reference is made to their practice of violently shaking the milk of their mares, for the purpose of causing a solid fatty matter to ascend to its surface, which, when removed from the milk, they considered a delicious article of food. Hippocrates, who wrote a little later than Herodotus, describes, but in clearer language, the manufacture of butter by the Scythians; he also alludes to the preparation of cheese by the same people. The word, butter, does not occur in any of Aristotle's writings, and although mention is made of it in the works of Anaxandrides, Plutarch, and Ælian, it is evident that they considered it only in the light of a curious substance, employed partly as an article of food, partly as a medicinal salve, by certain barbarous nations. About the second or third century, butter was but little known to the Greeks and Romans, and there is no reason to believe that it was ever generally used as an article of food by the classic nations of antiquity; it is noteworthy, that the inhabitants of the south of Europe even at the present time use butter in very small quantities, which, indeed, is often sold for medicinal purposes in the apothecaries' shops in Italy, Spain, and Portugal. From the foregoing statements it is evident that the butter manufacture can lay no claim to a classic origin; but that it took its rise in the countries of savage, of semi-civilised, and barbarous nations. It is probable that the Greeks were made acquainted with butter by the Thracians, Phrygians, and

Scythians; and that the knowledge of this substance was conveyed to Rome by visitors from Germany. During the middle ages the practice of butter-making spread throughout Northern, Central, and Western Europe; but in many parts the commodity was very scarce and highly valued, notwithstanding its being almost, if not quite, in a semi-fluid state, instead of possessing the firm consistence of the butter of the present day.

Irish Butter.—Butter is produced in such large quantities in Ireland that, after the home demand has been supplied, there remains a large excess—so considerable, indeed, as to constitute one of the more important of our few commercial staples. The precise quantity of butter which, during late years, has been annually exported from Ireland is unknown. The greater part of the commodity is sent to trans-Channel ports; and, there being no duty on butter in the cross-Channel trade since 1826, we have no means of accurately estimating the amount of our exports to Great Britain. If, however, we refer to the statistics of our commerce for the period beginning in 1787, and ending in 1826, we shall find that the exportation of butter was enormous, and that a large proportion of that commodity consumed by the army and navy was supplied from the dairies of Ireland. During the three years ended on the 5th of January, 1826, the average annual amount of butter exported was as follows:—

	cwts.
To Great Britain	441,226
To foreign countries	51,637

Of late years the exportation to foreign and colonial countries has fallen off; still the export trade is very considerable, probably amounting to 450,000 cwts. per annum. During the year 1867, the imports of foreign butter into Great Britain amounted to 1,142,262 cwts.

I have quoted the above statistics for the purpose of demonstrating the great importance of the butter trade to this country. Not only is a large proportion of the agricultural community pecuniarily interested in the production of this

article, but the exportation is the chief cause of the commercial prosperity of a city, which, in point of population, ranks third in the kingdom. If butter, then, be an article of so much importance, it is obvious that the greatest care should be taken in its preparation, and that the efforts of both scientific and practical men should be directed towards the best mode of improving its quality. If the principles involved in the production of butter were thoroughly understood, and generally known, I believe that such terms as "seconds," "thirds," and "fourths," would speedily fall into disuse; that there would be only one kind of butter sent into the market; and that the article would always be of the best quality, in other words, "firsts."

Composition of Butter.—The composition and quality of butter depend to a great extent upon the condition of the milk or cream from which it is prepared, and on the skill and cleanliness of the dairy-maid. It consists essentially of fatty and oily matters, but it is always found in combination with casein (cheesy matter) and water. The following analyses, made by Mr. Way, late consulting chemist to the Royal Agricultural Society of England, shows its composition :—

INGREDIENTS PER CENT.

	1.	2.	3.
Fatty matters	82.70	79.67	79.12
Casein	2.45	3.38	3.37
Water	14.85	16.95	17.51

No. 1 analysis shows the composition of a specimen obtained from the well-known Mr. Horsfall's dairy. It was made from raw cream. The other specimens were the produce of a Devonshire dairy, and were prepared from scalded cream. In several specimens of well-made and unsalted Irish butter which I have analysed, I found the proportion of casein or cheesy matter never to exceed 1 per cent., whilst in the analysis above stated the centesimal amount is on the average more than 3 per cent.

The fatty matter is composed of two substances—one, a

solid, termed *margarin;* the other fluid, and styled by chemists *elaine.* The solid fat is identical in composition with the solid fat of the human body. The elaine is peculiar to milk, but it differs very slightly from *olein*, or fluid fat. The relative proportions of the fluid and solid fats vary with the seasons. According to Braconnot, the solid fat forms in summer 40 per cent. of the butter, but in winter the proportion rises to 65. This decrease in the proportion of the liquid fat in winter is the cause of the greater hardness of the butter in that season, which is often incorrectly attributed solely to the cold.

The cheesy and acid matters contained in butter are by no means essential; on the contrary, if it were quite free from them, it might be retained with little or no salt for a very long period without becoming rancid. The cheesy matter contains nitrogen; and nearly all the substances into which this element enters as a constituent are remarkably prone to decomposition. Yeast, and ferments of every kind—gunpowder, fulminating silver, chloride of nitrogen—and almost every explosive compound, contain this element. The cheesy matter is a very nitrogenous body, and in presence of air and moisture not only rapidly decomposes, or decays, itself, but induces by mere contact a like state of decomposition in other substances—such, for instance, as fat, sugar, and starch, which naturally have no tendency to change their state. Bearing the foregoing facts in mind, it is obvious that the chief precautions to be observed in the manufacture of butter are:—Firstly, to separate to as great an extent as practicable the casein from the butter; and, secondly, as in practice a small portion of the curd remains in the butter, to prevent it from undergoing any change—at least for a prolonged period. How these desiderata may best be accomplished I shall now proceed to point out.

The Butter Manufacture.—The theory of the process of churning is very simple. By violently agitating the milk or cream the little vesicles, or bags containing the butter, are broken, and, the fatty matter adhering, *lumps of butter* are formed. The operation of churning also introduces atmo-

spheric air into the milk, which, aided by the high temperature to which the fluid is raised, converts a portion of the *sweet* sugar of milk into the *sour* lactic acid. By the alteration produced in this way in the composition of the milk, it is no longer capable of holding the casein in solution, and the curd therefore separates.

The churn and other vessels in which the milk is placed cannot be kept too clean. No amount of labor bestowed on the scalding and scrubbing of the vessels is excessive. When wood is the material used in the milk-pans the utmost care should be taken in cleaning them, as the porous nature of the material favors the retention of small quantities of the milk. A simple washing will not suffice to clean such vessels. They must be thoroughly scrubbed and afterwards well scalded with *boiling* water. Tin pans are preferable to wooden ones, as they are more easily cleaned, but in their turn they are inferior to glass vessels, which ought to supersede every other kind. Earthenware, lead, and zinc pans are in rather frequent use. The last-mentioned material is easily acted upon by the lactic acid of the sour milk, and is, therefore, objectionable. It is a matter of great importance that the dairy should not be situated near a pig-stye, sewer, or water-closet, the effluvia from which would be likely to taint the milk. It is surprising how small a quantity of putrescent matter is sufficient to taint a whole churn of milk; and as it has been demonstrated that the almost inappreciable emanations from a cesspool are capable of conferring a bad flavor on milk, it is in the highest degree important to remove from the churn and milk-pail every trace of the sour milk. I go further, it is even desirable that no one whose hands have a tendency to perspire should be allowed to manipulate in the dairy; and it should be constantly borne in mind that the dairy-maid's fingers and hot water should be on the most intimate visiting terms.

Butter is made either from cream—sour and sweet—or from whole milk which has stood sufficiently long to become distinctly sour. It is asserted by some makers that butter

prepared from whole milk, or from scalded cream, contains a large proportion of curd. If this be true—which I greatly doubt—it is a serious matter, for such butter would speedily become rancid in consequence of the casein acting as a ferment. I believe that experience points to an exactly opposite conclusion. From the results of careful inquiries I feel no hesitation in asserting that the butter should not be made from the cream, but from the *whole milk*. When made from the cream alone it is much more likely to acquire a bad taste, and is generally wanting in keeping qualities. I have no doubt but that in the process of churning the whole milk there is a large amount of lactic acid formed, and a much higher temperature attained, than in the churning of cream; consequently, the separation of caseous matter must be more perfectly effected in the former than in the latter case. It is a mistake to think that there is very little casein in cream: out of 7 or 8 lbs. of thick cream only a couple of pounds of butter are obtainable; the rest is made up of water, casein, and sugar of milk. The yield of butter is greater when the whole milk is churned than when the cream alone is operated upon, and, what is of great importance, the quality of the butter is uniform during the whole year. The labor of churning whole milk is, of course, much greater than if the cream alone were employed, but the increased yield and unvarying quality of the butter more than compensate for the extra expenditure of labor.

The proper temperature of the milk or cream is a point of great practical importance. If the fluid be too warm or too cold the buttery particles will only by great trouble be made to cohere; and the quality of the butter is almost certain to be inferior. When the whole milk is operated on, the temperature should be from 55 to 60 degs. of Fahrenheit's thermometer; and if cream be employed the temperature should never exceed 55 degs. nor be lower than 50 degs. Hence it follows that in summer the dairy should be kept cooler, and in winter warmer, than the atmosphere. The temperature of milk is raised or lowered as may be found necessary, by the addition of hot or cold

water—in performing which operations properly, a good thermometer is indispensable; one should always be kept in the dairy, and should be so constructed as to admit of being plunged into the milk. In some dairies the water, instead of being mixed with the milk, is put into a tub in which the churn is placed. There is a good kind of churn, which consists of two cylinders, the one within the other—the interval between them being intended for the reception of hot or cold water. The influence of temperature upon the production of butter has been placed beyond all doubt by numerous carefully-conducted experiments. Mr. Horsfall, a celebrated dairy farmer, in discussing this question, sums up as follows:—"By a series of carefully-conducted experiments at varying temperatures, I am of opinion that a correct scale of the comparative yield of butter at different temperatures might be arrived at; as thus: From a very low degree of temperature little or no butter; from a temperature of about 38 degs., 16 oz. from 16 quarts of milk; ditto, 45 degs., 21 oz. from 16 quarts of milk; ditto, 55 degs., 26 to 27 oz. from 16 quarts of milk." This is a higher yield of butter than, I suspect, most dairymen get: but Mr. Horsfall's cows being of the best kind for milking, and well fed, the milk is, of course, rich in butter; and his experiments prove that even the richest milk will not throw up its butter unless at a certain temperature.

In the churning of cream the motion should be slow at first until the cream is thoroughly broken up. In churning milk the agitation should neither be violent nor irregular; about 40 or 50 motions of the plunger or board per minute will be sufficient. In steam-worked churns the motion is often excessively rapid, and the separation of the butter is effected in a few minutes; but the article obtained in this hasty way very quickly becomes rancid, and must be disposed of at once. An hour's churning of sour cream appears in general to produce good butter. Sweet cream and whole milk require a longer period —the latter about 3 hours—but in any case prolonged churning is certain, by incorporating cheesy matter with the butter, to produce an inferior article.

Sweet milk becomes sour, evolves a considerable quantity of gas during churning, and its temperature ascends four or five degrees. Oxygen is unquestionably absorbed, and it is probable that a portion of the sugar of milk is converted into acid products.

I have already stated that even the most carefully prepared butter contains a small proportion of casein and sugar of milk. This casein is the good genius of the cheese-maker, but the evil genius of the butter manufacturer. How? In this way:—When butter containing a notable proportion of casein and sugar of milk is exposed to the air, the following changes take place: the casein passes into a state of fermentation, and acting upon the sugar of milk, converts it, firstly into the bad-flavored lactic acid, and secondly into the bad odorous butyric, capric, and caproic acids. The first of these compounds in a state of purity emits an odor resembling a mixture of vinegar and rancid butter; the second possesses an odor resembling that of a goat—hence the name *capric;* the third has an odor like that of perspiration. In addition to these acids, there is another simultaneously generated—the caprylic, but it does not unpleasantly affect the olfactory nerve. The casein also injuriously affects the fatty constituents of the butter; under its influence they absorb oxygen from the air, and become converted into strong-smelling compounds. The washing of butter is intended to free it from the casein and unaltered cream, and the more perfectly it is freed from those impurities the better will be its flavor, and the longer it will remain without becoming rancid. Some people believe that too much water injures the quality and lessens the quantity of butter. It cannot do the former, because the essential constituents of butter are totally insoluble in water; it may do the latter, but, if it do, so much the better, because the loss of weight represents the amount of impurities—milk, sugar of milk, &c.—removed.

I have already remarked that butter is so susceptible of taint that even a perspiring hand is sufficient to spoil it; naturally cool hands should alone be allowed to come in contact

with this delicate commodity, and the hands should be made thoroughly clean by repeated washings with warm water and oatmeal—the use of soap in the lavatory of the dairymaid being highly objectionable. Wooden spades are now being commonly made use of in manipulating the butter, and there is no good reason why they should not come into universal use.

The yield of butter per cow is subject to great variation. Some breeds of the animal are remarkable as milkers; such, for instance, as the Alderneys and Kerrys—indeed, I may say all the small varieties of the bovine race. There are instances of cows yielding upwards of twenty pounds of butter per week, but these are extraordinary cases. In Holland a good cow will produce, during the summer months, more than 180 lbs. of butter. In these countries I think the average annual yield of a cow is not more than 170 lbs. It sometimes happens that cows yield a large quantity of milk and a small amount of butter, but it far more frequently occurs that the cow which gives most milk also yields most butter.

An estimate of the amount of butter contained in milk may be made by determining the amount of cream. This may be effected by means of an instrument termed a *lactometer*, which is simply a glass tube about five inches long, and graduated into a hundred parts. The specimen to be examined is poured into this tube up to zero or 0, and allowed to stand for twelve hours in summer and sixteen or eighteen in winter. At the end of that time the cream will have risen to the top, and its per-centage may be easily seen. In good milk the cream will generally extend 11 to 15 degrees down from 0. This instrument, although very useful, is not reliable in every case, especially in detecting the adulteration of milk.

I have already stated that the complete separation of the butter from the other constituents of the milk is never accomplished in the dairy. Now although the proportion of curd in the butter is very small—rarely more than two per cent., and often not a fourth of one per cent.—yet it is more than sufficient, under a certain condition, to cause the butter to become

speedily rancid. That condition is simply contact with the air. If the curd, before it becomes dry and firm, is subjected to the influence of the air, it rapidly passes into a state of fermentation, which is very soon communicated to the fatty and saccharine constituents of the butter (substances not spontaneously liable to sudden changes in composition) and those peculiar compounds—such, for example, as butyric and capric acids, are generated, which confer upon rancid butter its characteristic and very disagreeable odor and flavor. The fermentation of the curd is prevented by incorporating common salt with the butter, and by preventing, so far as possible, the access of air to the vessels in which the article is placed. If fresh butter be placed in water—which apparently protects it from the influence of the air—it will soon become rancid. The reason of this is, that water always contains air, which differs in composition, though derived, from the atmosphere, by being very rich in oxygen. Now, it is precisely this oxygen which effects those undesirable changes in the casein, or curd, to which I have so repeatedly referred; hence its presence in a concentrated state in water causes that fluid to produce an injurious effect on the butter placed in it. A saturated solution of salt contains very little air, and, so long as the curd is immersed therein, it undergoes no change. The salt, too, acts as a decided preservative; for although it was long considered to be capable of preserving animal matters, merely by virtue of its property of absorbing water from them (the presence of water being a condition in the decomposition of organic matter), it has lately been shown to possess very antiseptic properties.

The mixing of the salt with the butter is effected in the following manner:—The butter,. after being well washed, in order to free it from the butter-milk, is spread out in a tub, and the salt shaken over it; the butter is then turned over on the salt by the lower part of the palm of the hand, and rubbed down until a uniform mixture is attained. A good plan in salting is to mix in only one half of the quantity of salt, make up the butter in lumps, and set them aside until the following

day; a quantity of milk is certain to exude, which is to be poured off, and then the rest of the salt may be incorporated with the butter.

According to butter-makers, the quality of the article is greatly dependent on the quality of the salt used in preserving it. I think there is a good deal of truth in this belief, and I therefore recommend that only the very best and *driest* salt should be used in the dairy. Common salt is essentially composed of the substance termed by chemists chloride of sodium, but it often contains other saline matters (chloride of magnesium, &c.), some of which have a tendency to absorb moisture from the air, and to dissolve in the water so obtained. These salts are termed *deliquescent*, from the Latin *deliquere*, to melt down. When, therefore, common salt becomes damp by mere exposure to the air, it is to be inferred that it contains impurities which, as they possess a very bitter taste, would, if mixed with butter, confer a bad flavor upon it. The impurities of salt may be almost completely removed by placing about a stone weight of it in any convenient vessel, pouring over it a quart of boiling water, and mixing thoroughly the fluid and solid. In an hour or two the whole is to be thrown upon a filter made of calico, when the water will pass through the filter, carrying with it all the impurities, and the purified salt, in fine crystals, will remain upon the filter. The solution need not be thrown away: boiled down to dryness it may be given as salt to cattle; or, if added in solution to the dung-heap, it will augment the fertilising power of that manure.

The proportion of salt used in preserving butter varies greatly. When the butter is intended for immediate use, I believe a quarter of an ounce of salt to the pound is quite sufficient; but when designed for the market, about half an ounce of salt to the pound of butter will be sufficient. Irish butter at one time commanded the highest price in the home and foreign markets, but latterly it has fallen greatly in public estimation; indeed, at the present moment the price of Irish butter at London is nearly twenty shillings per cwt. under that

of the Dutch article. It is really painful to be obliged to admit that the Irish farmer is solely to blame for this remarkable depreciation in the value of one of our best agricultural staples. In a word, by the stupid (and *recent*) practice of putting into butter four times the quantity of salt necessary to its preservation, the Irish dairy farmers—or at least the great majority of them—have completely ruined the reputation of Irish butter in those very markets in which, at one time, the Cork brand on a firkin was sufficient to dispose of its contents at the very highest price. It is a great mistake to think that the greater the quantity of salt which can be incorporated with the butter, the greater will be the profit to the producer. No doubt, every pound of salt sold as a constituent of butter realises a profit of two thousand per cent.; but then the addition of every pound of that substance, after a certain quantity, to the cwt. of butter depreciates the value of the latter to such an extent as to far more than neutralise the gain on the sale of salt at the price of butter. In the county of Carlow, less salt is used in preserving butter than is the case in the county of Cork and the adjacent counties; the price, therefore, which the Carlow commodity commands in the London market is higher than that of the Cork butter: but in every part of Ireland the proportion of salt added to the butter is excessive.

The results of the analyses of butter supplied to the London market, made by the *Lancet* Analytical Commission, showed that the proportion of salt varied from 0.30 to 8.24 per cent. The largest proportion of salt found in fresh butter was 2.21 and the least 0.30. In salt butter the highest proportion of salt was 8.24 and the lowest 1.53. The butter which contained most salt was also generally largely adulterated with water. Indeed, in several samples the amount of this constituent reached so high as nearly 30 per cent. Nothing is easier than the incorporation of water with salt butter. The butter is melted, and whilst cooling the salt and water are added, and the mixture kept constantly stirred until quite cold. In this way nearly 50 per cent. of water may be added to

butter; but of course the quality of the article will be of the very worst kind.

A correspondent of the *Lancet* states that, on awakening about three o'clock in the morning at the house in which he was lodging, he perceived a light below the door of his room; and apprehending a fire, he hurried down stairs, and was not a little surprised to discover the whole family engaged in manipulating butter. He was informed in a jocose way that they were making Epping butter! For this purpose they used inferior Irish butter, which, by repeated washings, was freed from its excessive amount of salt; after which it was frequently bathed in sweet milk, the addition of a little sugar being the concluding stroke in the process. This "sweet fresh butter from Epping" was sold at a profit of 100 per cent. Our dairy farmers might take a hint from this anecdote. Does it not prove that the mere removal of the salt added to Irish butter doubles the value of the article?

It is as necessary to pay attention to the packing of butter as it is to its salting. If old firkins be employed, great care should be taken in cleaning them, and if the staves be loose, the firkins should be steeped in hot water, in order to cause the wood to swell, and thereby to bring the edges of the staves into close contact. New firkins often communicate a disagreeable odour to the butter. In order to guard against this, it is the practice in many parts to fill the firkins with very moist garden mould, which, after the lapse of a few days, is thrown out, and the firkin thoroughly scrubbed with hot water, rinsed with the same fluid in a cold state, and finally rubbed with salt, just before being used.

In packing the butter, the chief object to be kept in view is the exclusion of air. In order to accomplish this, the lumps of butter should be pressed firmly together, and also against the bottom and sides of the vessel. When the products of several churnings are placed in the same firkin, the surface of each churning should be furrowed, so that the next layer may be mixed with it. A firkin should never be filled in a single

operation. About six inches of butter of each churning will be quite sufficient, and in a large dairy two or more firkins can be gradually but simultaneously filled. I strongly recommend the removal of the pickle jar from the dairy. When the layers of butter have been carried up to within an inch or so of the top of the firkin, the space between the surface of the butter and the edge of the vessel should be filled with fine dry salt, instead of pickle. A common mistake made is the holding over for too long a time of the butter: the sooner this article can be disposed of the better, for *it never improves by age.*

PART V.

ON THE COMPOSITION AND NUTRITIVE VALUE OF VEGETABLE FOODS.

SECTION I.

THE MONEY VALUE OF FOOD SUBSTANCES.

THE flesh-forming principles of food are, as I have already stated, almost identical with the principal nitrogenous constituents of animals. Unlike the non-plastic substances, they are convertible into each other with little, if any, loss either of matter or of force. Not many years since it was the fashion to estimate the nutritive value of a food-substance by its proportion of nitrogen; but this method—not yet quite abandoned—was based on erroneous views, and yielded results very far from the truth. No doubt all the more concentrated and valuable kinds of food are rich in nitrogenous principles; but there are other varieties, the nutritive value of which is very low, and yet their proportion of nitrogen is very high: This point requires explanation: Both the plastic and the non-plastic materials of food exist in two distinct states—in one of which they are easily digestible, and in the other either altogether unassimilable or so nearly so as to be almost useless. Thus, for example, the cellular tissue of plants, when newly formed, is to a great extent digestible, whilst the old woody fibre is nearly, if not quite, incapable of assimilation. Gelatine, which in raw bones is easily digested in the stomachs of the carnivora, loses a large proportion of its nutritive value on being

subjected to the action of steam. Again, a portion of the nitrogen of young succulent plants is in a form not sufficiently organic to admit of its being assimilated to the animal body. But, independently of these strong objections to the method of estimating the nutritive value of food by its per-centage of flesh-formers, there are many other reasons which as clearly prove the fallacy of this rule. If we were, for instance, to estimate the value of albumen according to the tables of food equivalents which were constructed some years ago by Boussingault and other chemists, we would find one pound weight of it to be equivalent to four pounds weight of oil-cake, or to twelve pounds weight of hay; yet, it is a fact that a horse would speedily die if confined to a purely albuminous diet, whereas hay is capable of supporting the animal's life for an indefinite period.

It is clear, then, from what I have stated, that neither the amount of flesh-formers, nor of fat-formers, contained in a given quantity of a substance is a measure of its nutritive value; nevertheless it would be incorrect to infer from this that the numerous analyses of feeding substances which have been made are valueless. On the contrary, I am disposed to believe that the composition of these substances, when correctly stated by the chemist, enables the physiologist to determine pretty accurately their relative alimentary value. Theory is certainly against the assumption that food is valuable in proportion to its content of nitrogen; nor has practice less strongly disproved its truth. An illustration drawn from the nutrition of plants will make this matter more apparent. Every intelligent agriculturist knows that guano contains nitrogen and phosphoric acid; both substances are indispensable to the development of plants, and therefore it would be incorrect to estimate the manurial value of the guano in proportion to the quantity of nitrogen it was capable of yielding. If the value of manures were determined only by their per-centage of nitrogen—a mode by which certain chemists still estimate the nutritive value of food—then woollen rags would be worth

more than bones, and bones would be more valuable than superphosphate of lime. The truth is, that the analysis of feeding stuffs and manures is sometimes of little value if the condition in which the constituents of these substances exist be undetermined. For example, the analysis of one manure may show it to contain 40 per cent. of phosphate of lime, and three per cent. of ammonia, whilst, according to analysis, another fertiliser may include 20 per cent. of phosphate of lime, and two per cent. of ammonia. Viewed by this light solely, the first manure would be considered the more valuable of the two, whereas it might, in reality, be very much inferior. If the phosphate of lime in the manure, containing 40 per cent. of that body, were derived from coprolites or apatite, and its ammonia from horns, the former would be worth little or nothing, and the latter, by reason of its exceedingly slow evolution from the horns, would possess a very low value. If, on the contrary, the phosphate of lime, in the manure comparatively poor in phosphate, were a constituent of bones, and its ammonia ready formed (say as sulphate of ammonia), then, its value, both commercial and manurial, would be far greater than the other.

In estimating the money value of an article of food, we should omit such considerations as the relative adjustment of its flesh-formers and fat-formers, and its suitability to particular kinds of animals, as well as to animals in a certain stage of development. The manure supplied to plants contains several elements indispensable to vegetable nutrition; and, although the agriculturist most commonly purchases all these elements combined in the one article, still he frequently buys each ingredient separately. Ammonia is one of these principles, and, whether it be bought *per se*, or as a constituent of a compound manure, the price it commands is invariable. This principle should prevail in the purchase of food: each constituent of which should have a certain value placed upon it; and the sums of all the values of the constituents would then be the value of the article of food taken as a whole. There

are, no doubt, practical difficulties in the way which prevent this method of valuation from giving more than approximatively correct results; but are there not precisely similar difficulties in the way of the correct estimation of the value of a manure according to its analysis? There are several constituents of food, the money value of which is easily determinable: these are sugar, starch, and fat. No matter what substance they are found in, the nutritive value of each varies only within very narrow limits. The value of cellulose and woody fibre is not so easily ascertained, as it varies with the age and nature of the vegetable structure in which these principles occur. There is little doubt but that the cellulose and fibre of young grass, clover, and other succulent plants, are, for the most part, digestible; and we should not be far astray if we were to assume that four pounds weight of soft fibre and cellulose are equivalent to three pounds weight of starch. As to old hard fibre, we are not in a position to say whether or not it possesses any nutrimental value worth taking into account. The estimation of the value of the flesh-forming materials is far more difficult than that of sugar, starch, pectine compounds, and fat. The nitrogenous constituents of food must be in a highly elaborated state before they are capable of being assimilated. In seeds—in which vegetable substances attain their highest degree of development—they probably exist in the most digestible form, whilst much of the nitrogen found in the stems and leaves of succulent plants, is either in a purely mineral state, or in so low a degree of elaboration as to be unavailable for the purpose of nutrition. But even plastic materials, in a high degree of organisation, present many points of difference, which greatly affect their relative alimental value; for example, many of them are naturally associated with substances possessing a disagreeable flavor: and as their separation from these substances is often practically impossible, the animal that consumes both will not assimilate the plastic matters so well as if they were endowed with a pleasant flavor. In seeds and other perfectly matured

vegetable structures, the flesh-formers may exist in different degrees of availability. The nitrogen of the *testa*, or covering of the seeds, will hardly be so assimilable as that which exists in their cotyledons. The solubility of the flesh-formers—provided they be highly elaborated—is a very good criterion of their nutritive power. In linseed the muscle-forming substances are more soluble than in linseed-cake—the heat which is generally employed in the extraction of oil from linseed rendering the plastic materials of the resultant *cake* less soluble, and diminishing thereby their digestibility, as practice has proved.

From the considerations which I have now entered into, it is obvious that the chemical analysis of food substances as generally performed, though of great utility, does not afford strictly accurate information as to their commercial value, and still less reliable in relation to their nutritive power. At the same time, they as clearly establish the feasibility of analyses being *made* whereby the money value of feeding-stuffs may be estimated with tolerable exactitude. Let the chemist determine the presence and relative amounts of the ingredients of food-substances, and—if it be possible so to do with a degree of exactness that would render the results useful—place on each a money value. This done, let the physiologist and the feeder combine the food in such proportions as they may find best adapted to the nature, age, and condition of the animal to be fed.

It is to be regretted that the market price of feeding stuffs is not, in consequence of our defective knowledge, strictly determined by their nutritive value, for if such were the case, the feeder would merely have to adapt each to the nature and condition of his stock. Even amongst practical men there prevails, unfortunately, great diversity of opinion as to the relative nutritive value of the greater number of food substances; and I am quite certain that many of these command higher prices than others which in no respect are inferior. It would lead me too far from my immediate subject were I to

enter minutely into the consideration of such questions as —whether an acre of grass yields more or less nutriment than an acre of turnips? I shall merely describe the composition and properties of grass and of turnips, and of the various other important food substances, and compare their nutritive power, so far as comparisons are admissible; but I shall say but little on the subject of the various economic and other conditions which affect the production of forage plants. When I shall have described the chemical nature and physical condition of the various articles of food, and the results of actual feeding experiments made with them, the feeder will then be in a position to determine which are the most economical to produce or to purchase.

SECTION II.

PROXIMATE CONSTITUENTS OF VEGETABLES.

The saccharine, or amylaceous substances constitute the most abundant of the proximate constituents of plants. They are composed of carbon, hydrogen, and oxygen. I shall briefly describe the more important members of this group of substances, namely, starch, sugar, inulin, gum, pectin, and cellulose.

Starch, or *fecula*, occurs largely in dicotyledonous seeds, peas, &c., and still more abundantly in certain monocotyledonous seeds, such as wheat and barley. It constitutes the great bulk of many tubers and roots—for example, the potato and tapioca. It consists of flattened ovate granules, which vary in size according to the plant. In the beetroot they are $\frac{1}{3500}$ of an inch in diameter, whilst in *tous les mois* they are nearly $\frac{1}{200}$ of an inch in diameter. Most of the starch granules are marked by a series of concentric rings. Starch is heavier than water, and is insoluble in that fluid when cold; neither is it dissolved by alcohol or ether. When heated in water having a temperature of at least 140° Fahrenheit, it increases greatly in volume, and acquires a gelatinous consistence. When the

water is allowed to cool, a portion of the starch becomes insoluble, whilst another portion remains in solution; the latter form of starch is sometimes termed *amidin*, from the French word for starch, *amidon*. When dry starch is heated to 400° Fahr., it is converted, without any change in its composition, into a soluble gum-like substance, termed *dextrin*, or British gum. On being boiled in diluted sulphuric acid it is converted into a kind of sugar; and the same effect is produced by fermentation—for example, in the germination of seeds. Fresh rice contains 82, wheat 60, and potatoes 20 per cent. of starch. This substance constitutes a nutritious and easily digestible food, but alone cannot support life. Arrowroot is only a pure form of starch.

Sugar occurs less abundantly in plants than starch. There are several varieties of this substance, of which the kinds termed cane sugar (*sucrose*) and grape sugar (*glucose*), are only of importance to agriculturists. The former enters largely into the composition of the sugar-cane, the beetroot, the sugar-maple, the sorgho grass, pumpkins, carrots, and a great variety of other plants. Grape sugar is found in fruits, especially when dried—raisins and figs—in malted corn, and in honey. In the sugar-cane there is 18 per cent., and in the beetroot 10 per cent. of sugar.

Cane sugar, when pure, consists of minute transparent crystals. It is $1\frac{6}{10}$ heavier than water, and is soluble in one-third of its weight of that fluid. By long-continued boiling in water it is changed into uncrystallizable sugar, or treacle, by which its flavor is altered, but its sweetening power increased.

Grape sugar crystallizes in very small cubes, of inferior color as compared with cane sugar crystals. It dissolves in its own weight of water, being three times less soluble than sucrose. In sweetening power one part of cane sugar is equal to $2\frac{1}{2}$ parts of grape sugar; but there is probably little if any difference, between the nutritive power of the two substances.

Inulin is a substance somewhat resembling starch. It does

not occur in large quantities. It is met with in the roots of the dandelion, chicory, and many other plants.

Gum is an abundant constituent of plants. The kind termed gum arabic, so largely employed in the arts, is a very pure variety of this substance. Common gums are said to be essentially composed of a very weak acid—*gummic*, or *arabic* acid—united with lime and potash. The solution of gum is very slightly acid, and has a mucilaginous, ropy consistence: it is almost tasteless. *Mucilage*, or *bassorin*, is simply a modified form of gum, which, though insoluble in water, forms a gelatinous mixture with that fluid. It exudes from certain trees—the cherry for example—and exists largely in linseed and other seeds. Gums are nutritious foods, but it is probable that they are not equal in alimental power to equal weights of starch or sugar.

Vegetable jelly, or *pectin*, is almost universally diffused throughout the vegetable kingdom. It is owing to its presence that the juices of many fruits and roots possess the property of gelatinizing. It is soluble in water, but prolonged boiling destroys its viscous property. *Pectose* is a modification of pectin; it is insoluble in water. According to Fremy, the hardness of green fruits is due to the presence of pectose; which is also found in the cellular tissue of turnips, carrots, and various other roots.

Cellulose is a fibrous or cellular tissue, allied in composition to starch. It is the most abundant constituent of plants, and forms the very ground-work of the vegetable mechanism. Linen, cotton, and the pith of the elder and other trees are nearly pure forms of cellulose. Ligneous, or woody tissue (*lignin*) is indurated cellulose, hardened by age. It is almost identical in composition with cellulose. Pure cellulose is white, colorless, tasteless, insoluble in water, oil, alcohol, or ether. It is heavier than water. Sulphuric acid is capable of converting it into grape, or starch sugar. In its fresh and succulent state cellulose is digestible and nutritious; but in the form of ligneous tissue it opposes a very great resistance to the action of the digestive

fluids. Digestible cellulose is probably equal in nutritive power to starch.

Oils and fats occur abundantly in vegetables, more particularly in their seeds. In the seeds of many cruciferous plants the proportion of fat and oil exceeds 35 per cent. The oils and fats termed *fixed* are those which possess the greatest interest to agriculturists; the *volatile oils* being those which confer on certain plants their fragrant odour. There are a great variety of vegetable oils, but the proximate constituents of most of them are chiefly *stearin*, *margarin*, *olein*, and *palmitin*.

Stearin is a white crystalline substance, sparingly soluble in alcohol and ether, but insoluble in water. There are two or three modifications of this substance, but they do not essentially differ from each other. The melting point varies from 130° to 160° Fahr. Stearin is the most abundant of the fats.

Margarin presents the appearance of pearly scales. It is the solid fat present in olive oil, and it is also met with in a great variety of fats and oils. It melts at 116° Fahr.

Olein is the fluid constituent of oils and fatty substances. It resists an extreme degree of cold, without solidifying. There are several modifications of this body—the olein of olive oil being somewhat different from that of castor oil; the olein of linseed is sometimes termed *linolien*.

Palmitin.—This fat occurs in many plants, but as it makes up the great bulk of palm oil, it has been termed palmitin. It is white, and may be obtained in feathery-like masses. Its melting point varies from 114° to 145°, there being, according to Duffy, three modifications of this substance.

The fats and oils are lighter than water. They contain far more carbon and hydrogen, and less oxygen, than are found in the sugars and starches. They all consist of acids (stearic, palmitic, &c.) united with glycerine. On being boiled with potash or soda, the latter take the place of the glycerine, which is set free, and a *soap* is produced. The fatty acids strongly resemble the fats. In nutritive power, one part of fat is equal to 2½ parts of starch or sugar.

The Albuminous substances contain, in addition to the elements found in starch, nitrogen, sulphur, and phosphorus. *Albumen*, *fibrin*, and *legumin* constitute the three important members of the "Nitrogenous" constituents of plants.

Albumen is an uncrystallizable substance. It is soluble in water, unless when heated to 140 deg. Fahr., at which temperature it coagulates, *i.e.*, becomes solid and insoluble. The *gluten* of wheat is composed chiefly of albumen, and of bodies closely allied to that substance.

Fibrin, when dried, is a hard, horny, yellow, solid body. It contains a little more oxygen than is found in albumen. This substance is best known as a constituent of animals, and it does not appear to be abundant in plants. The portion of the gluten of wheat-flour, which is insoluble in boiling alcohol, is considered by Liebig and Dumas to be coagulated fibrin.

In the seeds of leguminous and a few other kinds of plants large quantities of a substance termed *legumin* are found. It resembles the casein, or cheesy ingredient of milk; indeed, some chemists consider it to be identical in composition with that substance. When pure, it is pearly white, insoluble in boiling water, but soluble in cold water and in vinegar. The saline matters found in plants are always associated with the albuminous bodies; the latter, therefore, form the bones as well as the muscles of animals.

A great many substances are found in plants, such as wax, mannite, "extractive matter," citric, malic, and other acids, of the nutritive value of which very little is known. The substances described in this section constitute, however, at least 95 per cent. of the weight of the vegetable matters used as food by live stock.

SECTION III.

GREEN FOOD.

The Grasses.—More than one-half the area of Great Britain and Ireland is under pasture; the grasses, therefore, constitute the most important and abundant food used by live stock.

The composition of the natural and artificial grasses is greatly influenced by the nature of the soil on which they are grown, and by the climatic conditions under which they are developed. Many of them are almost worthless, whilst others possess a high nutritive value. Amongst the most useful natural grasses many be enumerated Italian rye-grass, Meadow barley, Annual Meadow-grass, Crested dogstail-grass, Cocksfoot-grass, Timothy or Meadow catstail-grass, and Sweet vernal-grass. Amongst grasses of medium quality I may mention common Oatlike-grass, Meadow foxtail grass, Smooth and rough stalked Meadow-grass, and Waterwhorl-grass. There are very many grasses which are almost completely innutritious, and which ought, under no circumstances, to be tolerated, although too often they make up the great bulk of the herbage of badly-managed meadows and pastures. Such grasses are, the Meadow soft-grass, Creeping soft-grass, False brome-grass, and Upright brome-grass. The rough-stalked Meadow-grass, though spoken favorably of by some farmers, is hardly worthy of cultivation, and the same may be said of many of the grasses which have a place in our meadows and pastures. (See "Analyses of Natural Grasses in a Fresh State, by Dr. Voelcker," on next page.)

The *Schræder brome* is a perennial lately introduced into France. It is described as an exceedingly valuable forage crop, and one which is admirably adapted for the feeding of dairy cows. It would be desirable to give it a trial in these countries. The composition (which is very peculiar) of this plant is stated to be as follows, when dry:—

ANALYSIS OF SCHRÆDER BROME HAY.

Water	16·281
Nitrogenous matters	23·443
Fat	3·338
Starch gum, &c.	22·549
Cellulose (fibre)	19·843
Ashes	14·546
Total	100·000

ANALYSES OF NATURAL GRASSES IN A FRESH STATE, BY DR. VOELCKER.

	Water.	Albuminous or Flesh-forming Principles.	Fatty Matters.	Respiratory Principles: Starch, Gum, Sugar.	Woody Fibre.	Mineral Matter or Ash.	Date of Collection.
Anthoxanthum odoratum — Sweet-scented vernal grass	80·35	2·00	·67	8·54	7·15	1·24	May 25
Alopecurus pratensis—Meadow foxtail grass.	80·20	2·44	·52	8·59	6·70	1·55	June 1
Arrhenatherum avenaceum—Common oat-like grass	72·65	3·54	·87	11·21	9·37	2·36	July 17
Avena flavescens—Yellow oat-like grass ...	60·40	2·96	1·04	18·66	14·22	2·72	June 29
,, pubescens—Downy oat-grass	61·50	3·07	·92	19·16	13·34	2·01	July 11
Briza media—Common quaking grass	51·85	2·93	1·45	22·60	17·00	4·17	June 29
Bromus erectus—Upright brome grass... ...	59·57	3·78	1·35	33·19		2·11	,, 23
,, mollis—Soft brome grass	76·62	4·05	·47	9·04	8·46	1·36	May 8
Cynosurus cristatus—Crested dogstail grass..	62·73	4·13	1·32	19·64	9·80	2·38	June 21
Dactylus glomerata—Cocksfoot grass	70·00	4·06	·94	13·30	10·11	1·54	,, 13
Ditto, seeds ripe	52·57	10·93	·74	12·61	20·54	2·61	July 19
Festuca duriuscula—Hard fescue grass... ...	69·33	3·70	1·02	12·46	11·83	1·66	June 13
Holcus lanatus—Soft meadow grass	69·70	3·49	1·02	11·92	11·94	1·93	,, 29
Hordeum pratense—Meadow barley	58·85	4·59	·94	20·05	13·03	2·54	July 11
Lolium perenne—Darnel grass	71·43	3·37	·91	12·08	10·06	2·15	June 8
,, italicum—Italian rye-grass	75·61	2·45	·80	14·11	4·82	2·21	,, 13
Phleum pratense—Meadow catstail grass ...	57·21	4·86	1·50	22·85	11·32	2·26	...
Poa annua—Annual meadow grass	79·14	2·47	·71	10·79	6·30	·59	May 28
,, pratensis—Smooth-stalked meadow grass	67·14	3·41	·86	14·15	12·49	1·95	June 11
,, trivialis—Rough-stalked ditto ...	73·60	2·58	·97	10·54	10·11	2·20	,, 18
Grass from water meadow	87·58	3·22	·81	3·98	3·13	1·28	April 30
Ditto, second crop	74·53	2·78	·52	11·17	8·76	2·24	June 26
Annual rye-grass	69·00	2·96	·69	12·89	12·47	1·99	,, 8

Most of the grasses here mentioned were analysed when in flower.

Tussac Grass (*Dactylis cæspitus*) is recommended as an excellent plant to grow on very poor, wet, or mossy soils.* It is an evergreen grass, somewhat resembling coltsfoot. It is relished by cattle.

ANALYSIS OF TUSSAC GRASS BY JOHNSTONE.

	Lower part.	Upper part.
Water	86·09	75·17
Flesh-formers	2·47	4·79
Sugar, gum, &c.	4·62	6·81
Woody fibre (with a little albumen)	5·68	11·86
Ash	1·14	1·37
Total	100·00	100·00

The "artificial grasses" embrace the clovers, vetches, lucerne, and a few other plants, some of which are seldom cultivated.

ANALYSES OF DIFFERENT KINDS OF CLOVER, BY DR. ANDERSON.

	Per-centage in the Fresh Clover.				Per-centage in Dry Clover.	
	Water.	Dry Substances.	Ash.	Nitrogenised Substances.	Ash.	Nitrogenised Matters.
Red clover—Trifolium pratense:						
1. From English seed...	85·30	14·70	1·30	2·31	8·90	15·87
2. From German seed (from the Rhine) ...	81·68	18·32	1·49	2·81	8·15	15·50
3. From French seed ...	83·51	16·49	1·95	2·25	11·82	13·56
4. From American seed	79·98	21·02	1·58	2·87	8·05	...
5. From Dutch seed ...	...	...	...	...	8·82	12·43
Cowgrass — Trifolium medium: †						
Variety, Duke of Norfolk	77·39	22·61	2·73	2·25	12·09	10·19
,, common	81·76	18·24	1·92	3·19	10·53	14·37
Crimson clover, Trifolium incarnatum:						
From French seed ...	82·56	17·44	1·88	3·25	10·81	18·56
Yellow clover — Medicago lupulina:						
From English seed ...	77·38	22·62	2·02	3·50	8·95	15·44
From French seed ...	78·60	21·40	1·75	2·94	8·18	13·69

* See Transactions of Highland and Agricultural Society of Scotland for 1852.

† Zig-zag clover, or Marl grass? Cowgrass is *Trifolium pratense perenne*.

Clover is very rich in flesh-forming and heat-producing substances. There are several varieties of this plant, of which the Alsike Clover appears to be the most valuable, as it contains a high proportion of organic matter and gives the largest acreable produce. The nature of the soil influences, to a great extent, the composition of this plant: this no doubt accounts for the somewhat discrepant result of the analyses of it made by Way, Voelcker, and Anderson.

The composition of the Vetch, Sainfoin, and Lucerne, resembles very closely that of the Clover: indeed, it appears to me that all these leguminous plants are nearly equally valuable as green forage, but that the best adapted for hay is the Clover. In the following table the composition of these plants is shown:—

ANALYSES OF CLOVER, BY DR. VOELCKER.

	I. Red Clover.	II. White Clover.	III. Yellow Clover.	IV. Alsike. Clover.	V. Bokhara Clover.
Water	80·64	83·65	77·57	76·67	81·30
Soluble in Water—					
a. Organic substances.	6·35	4·98	8·26	4·91	6·80
b. Inorganic substances	1·55	1·13	1·40	1·33	1·54
Insoluble in water—					
a. Impure vegetable fibre	11·04	9·80	12·17	16·36	10·01
b. Inorganic matters (ash)	0·42	0·44	0·60	0·73	0·35
	100·00	100·00	100·00	100·00	100·00

ANALYSES OF LUCERNE, SAINFOIN, AND VETCH.

	I. Lucerne.	II. Sainfoin.	III. Vetch.
Water	73·41	77·32	82·16
Soluble in Water—			
a. Organic substances	9·43	8·00	6·07
b. Inorganic substances	2·33	1·20	1·07
Insoluble in water—			
a. Impure vegetable fibre...	14·08	12·95	10·23
b. Inorganic matters (ash)	0·75	0·53	0·47
	100·00	100·00	100·00

The artificial grasses are, on the whole, more nutritious than the natural grasses; but I should explain that the analyses of the natural grasses which I have quoted refer to those plants in what may be almost termed their wild state: under the influence of good cultivation—when irrigated or top-dressed with abundance of appropriate manure—their analyses would indicate a higher nutritive value. The grasses, and more especially the so-called artificial grasses, are more nutritious and digestible when young. In old clover the proportion of insoluble woody fibre is often so considerable as to greatly detract from the alimental value of the plant.

The *Lentils*, the *Birdsfoot*, the *Trefoil*, and the *Melilot* are leguminous plants which occasionally are found as constituents of forage crops. Lentils are extensively cultivated on the Continent, and are the only kind of these plants the chemistry of which has been at all studied. The straw contains 7 per cent. of flesh-formers.

The Yellow Lupine is cultivated rather extensively in Germany, France, and Belgium, partly for feeding purposes, partly to furnish a green manure. Its seeds constitute a nutritious article of food for man, and its stems and leaves are given to cattle. An attempt was made a few years ago to introduce its cultivation, as a field crop, into England, and very satisfactory results attended the first trials made with it. Mr. Kimber, who has cultivated this crop, states that it is likely to prove valuable on light sandy soils, where the ordinary green fodder crops are not easily cultivated. The produce per acre obtained in Mr. Kimber's trial was about nineteen tons. Cattle and sheep relish the Yellow Lupine, but according to Mr. Kimber, pigs reject it. Professor Voelcker examined this plant, and found that it resembled in composition the ordinary artificial grasses, except in one respect, namely, a remarkable deficiency in sugar. Altogether, it is not so rich in nutriment as any of the commonly cultivated leguminous plants; but as it can be cultivated on a very poor soil, and gives a good return, it is probable that the Yellow Lupine will yet become a common crop

in Britain. The following table exhibits the results of Dr. Voelcker's analysis.

COMPOSITION OF YELLOW LUPINES (CUT DOWN IN A GREEN STATE).

	In natural state.	Dried at 212°F.
Water	89·20	
Oil	·37	3·42
*Soluble albuminous compounds ...	1·37	12·68
Soluble mineral (saline) substances ...	·61	5·64
†Insoluble albuminous compounds ...	1·01	9·35
Sugar, gum, bitter extractive matter, and digestible fibre	3·96	36·68
Indigestible woody fibre (cellulose) ...	3·29	30·48
Insoluble mineral matters	·19	1·75
	100·00	100·00
* Containing nitrogen	·22	2·03
† Containing nitrogen	·16	1·48

Rib grass plantain (Plantago lanceolata) is one of those plants, the value of which for forage purposes is questionable. Many persons believe it to be a useful food. Its composition, which looks favorable, is as follows :—

Water	84·78
Albuminous matters	2·18
Fatty matters	0·56
Starch, gum, &c.	6·08
Woody fibre	5·10
Mineral matter	1·30

The grasses, natural and artificial, are occasionally affected by a formidable and well-known fungus, the *ergot.* Italian rye-grass is the most liable to the ravages of this pest, and there are on record several cases in which ergotted rye-grass proved fatal to the animal fed upon it. Clover and the various leguminous plants appear more liable to the ergot disease than the natural grasses (except rye-grass), but I have on several occasions noticed this fungus on the spikelets of *Hordeum pratense, Festuca pratense,* and *Bromus erectus.* It has also been noticed that rye-grass rapidly developed under the influence of liquid manure is so rank that young animals fed upon it are poisonously affected.

Alderman Mechi states that in July, 1864, ten out of his thirty Shorthorn calves died in consequence of eating the heads of Italian rye-grass, and that the survivors' health was seriously injured. He was also unfortunate with his lambs, which, during the same month, were folded on Italian rye-grass. "Four days ago," writes the Alderman, "it was sewaged, having been prior to the former growth also guanoed. In four days it had grown from four to five inches, was of an intense green, and pronounced to be, by sharp practical men, just the food for lambs. Well, we put on our lambs, taking care to do so in the evening, after they had been well fed. My bailiff accompanied them, and, within five minutes, turning accidentally round, he saw two of the lambs with their heads in the air staggering (stomach staggers it is called) and frothing at the mouth. He immediately saw the mischief, removed the lambs, and on their way back to a bare fold some of them vomited the Italian rye-grass that they had just eaten, accompanied by frothy slime; others brought it up during the night. Some of them trembled, gaped, and showed all the same symptoms that my calves had done, such as rapid pulse, &c. Two or three of them are rather queer to-day. I hope that Professor Simmonds or some capable person will tell us how this is? If we mow this grass, bring it home, and cut it into chaff, all which tends to heat or dry it, it becomes wholesome food. The same remarks apply in degree to very succulent tares. If the Italian grass is brought home and given long and quite fresh to the calves, it will kill them. It does not appear to injure old ewes as it does lambs or shearlings. The dry weather has something to do with it. In wet weather the evil is much diminished, or disappears."

It is probable that the juice of this poisonous herbage was extremely rich in matters only semi-organised, and perhaps abounded in the crude substances from which the vegetable tissues are elaborated. Such rank grass as this was should not be used until it has attained to a tolerably developed state: in mature plants the juices contain more highly organised matters than are found in young vegetables.

The *Sorghuo, or Holcus Saccharatus.*—This plant, introduced to the notice of the British farmer but a few years ago, is only grown in these countries in small quantities. It is very rich in sugar, and cattle relish it greatly. Its composition, according to Dr. Voelcker, is as follows :—

Water	81·80
Albuminous matters	1·53
Insoluble ditto	0·66
Sugar	5·85
Wax and fatty matter	2·55
Mucilage, pectin, and digestible matters ...	2·59
Indigestible woody fibre	4·03
Mineral matter	0·99
	100·00

The plants referred to in the above analysis were cut in September. It is found that the composition of the plant is very different at different seasons.

Green Rye is employed as a forage crop, for which purpose it is well adapted. It is about equal in nutritive power to clover. According to Dr. Voelcker its composition is as follows :—

Water	75·423
Flesh-formers	2·705
Fatty matter	0·892
Gum, pectin, sugar, &c.	9·134
Woody-fibre	10·488
Mineral matter	1·358
	100·000

Buckwheat is occasionally cut in a green state and used as food for stock. Its composition, according to Einhof and Crome, is as follows :—

Water	82·5
Nitrogenous compounds	0·2
Extractive matters	2·6
Starch, &c.	4·7
Cellulose	10·0
	100·0

Rape is one of our most valuable plants for stock feeding. Two varieties are cultivated in these countries—the summer rape (*Brassica Campestris oleifera*) and winter rape (*Brassica rapus*). The great utility of rape arises from the circumstance of its being generally obtained as a *stolen* crop; for otherwise it is not quite equal to other plants that might be substituted for it—cabbages, &c. This plant is very rich in oily matters, and has been found well adapted both for the feeding of cattle and the fattening of sheep. Its composition, according to Voelcker, is shown in this table:—

COMPOSITION OF GREEN RAPE.

Water	87·050
Flesh-formers	3·133
Fatty matters	0·649
Other respiratory substances	4·000
Woody fibre	3·560
Mineral matter (ash)	1·608
	100·000

With respect to the value of rape for the feeding of stock in spring, Mr. Rham makes the following remarks:—

If the crop is very forward it may be slightly fed off, but in general it is best to let it remain untouched till spring. In the end of March and the beginning of April it will be a great help to the ewes and lambs. It will produce excellent food till it begins to be in flower, when it should immediately be ploughed up. The ground will be found greatly recruited by this crop, which has taken nothing from it, and has added much by the dung and urine of the sheep. Whatever be the succeeding crop, it cannot fail to be productive; and if the land is not clean, the farmer must have neglected the double opportunity of destroying weeds in the preceding summer, and in the early part of spring. If the rape is fed off in time, it may be succeeded by barley or oats, with clover or grass seeds, or potatoes, if the soil is not too wet. Thus no crop will be lost, and the rape will have been a clear addition to the produce of the land. Any crop which is taken off the land in a green state, especially if it be fed off with sheep, may be repeated without risk of failure, provided the land be properly tilled; but where cole or rape have produced seed, they cannot be profitably sown in less than five or six years after on the same land. The cultivation of rape or cole for spring food cannot be too strongly recommended to the farmers of heavy clay soils.

The Mustard Plant is occasionally used as food for sheep, for which purpose its composition shows it to be well adapted. Voelcker's analysis proves it to be very rich, relatively, in muscle-forming elements and in mineral matters; it might, therefore be with advantage combined with food relatively deficient in these principles.

COMPOSITION OF FRESH MUSTARD.

Water	86·30
Albuminous matters	2·87
Non-nitrogenous matters (gum, sugar, oil, &c.)	4.40
Woody fibre	4·39
Ash	2·04
	100·00

The Prickly Comfrey has been recommended as a good forage plant. It yields an abundant crop—or rather crops, for it may be cut several times in the year. The plant is a handsome one, and it might combine the useful with the ornamental, if it were cultivated on demesne or villa farms. Dr. Voelcker states its composition to be as follows:—

Water	88·400
Flesh-forming substances	2·712
Heat and fat-producing matters	6·898
Ash	1·990
	100·000

Chicory is used as a forage crop on the Continent, and Professor John Wilson surmises that it may yet be generally cultivated for this purpose in Great Britain. At present it is rarely grown except for the sake of its roots, which are used as partial substitutes for, or adulterants of, coffee.

COMPOSITION OF CHICORY, ACCORDING TO ANDERSON.

	Fresh roots.	Fresh leaves.
Water	80·58	90·94
Nitrogenous matters	1·72	1·01
Non-nitrogenous substances ...	16·39	6·63
Ash	1·31	1·42
	100·00	100·00

Yarrow (*Achillæa millefolium*) is usually regarded as a weed, but sheep are very fond of it, and when they can get it, never fail to eat it greedily. It possesses astringent properties. Some writers have recommended it as a good crop for warrens and sands. Its composition, according to Way, is as follows :—

DRIED YARROW.

Albuminous matter	10·34
Fatty matters	2·51
Starch, gum, &c.	45·46
Woody fibre	32·69
Mineral matter	9·00
	100·00

Melons and *Marrows* have been used, but to a very limited extent, as food for stock. Mr. Blundell advocates their use in seasons of drought. He states that he has obtained more than forty tons per acre of both melons and marrows. They are relished by horses, oxen, sheep, and pigs. Mr. Blundell's advocacy has not been attended with much success, but it would be desirable to give these vegetables a further trial.

Dr. Voelcker's analysis of the cattle melon shows that it contains :—

Water	92·98
Albuminous matters	1·53
Oil	·73
Sugar, gum, &c.	2·51
Fibre	1·65
Ash	·60
	100·00

The Cabbage.—The composition of the Drumhead Cabbage has been studied by Dr. Anderson. He found a larger proportion of nutriment in the outer leaves than in the "heart," and ascertained that the young plants were richer in nutriment than those more advanced in age. His results show the desirability of cultivating the open-leaved, rather than the compact varieties of this plant.

ANALYSIS OF THE CABBAGE.—BY DR. ANDERSON.

	Outer leaves.	Heart leaves.
Water	91·08	94·48
Compounds containing nitrogen ...	1·63	0·94
Compounds destitute of nitrogen, such as gum, sugar, fibre, &c....	5·06	4·08
Ash (mineral matter)	2·23	0·50
	100·00	100·00

According to Fromberg, the composition of the whole plant is as follows :—

Water	93·40
Nitrogenous, or flesh-forming compounds	1·75
Non-nitrogenous substances, such as gum, sugar, &c.	4·05
Mineral matter	0·80
	100·00

Dr. Voelcker, who has more recently analysed the cattle cabbage, furnishes us with the following details of its composition :—

COMPOSITION OF CABBAGE LEAVES (OUTSIDE GREEN LEAVES).

Water	83·72
Dry matter	16·28
	100·00

The fresh and the dry matter consisted of :—

	Fresh Matter.	Dry matter. Per cent.
*Protein compounds	1·65	10·19
Non-nitrogenous matter	13·38	82·10
Mineral matter	1·25	7·71
	16·28	100·00
* Containing nitrogen	·26	1·63

In the following table the results of a more elaborate analysis of the *heart* and inner leaves are shown :—

COMPOSITION OF HEART AND INNER LEAVES.

	In natural state.	Dry.
Water	89·42	
Oil	·08	·75
*Soluble protein compounds ...	1·19	11·24
Sugar, digestible fibres, &c. ...	7·01	66·25
Soluble mineral matter	·73	6·89
†Insoluble protein compounds ...	·31	2·93
Woody fibre	1·14	10·77
Insoluble mineral matter	·12	1·17
	100·00	100·00
* Containing nitrogen	·19	1·79
† Containing nitrogen	·05	·47

If I were asked what plant I considered the most valuable for forage, I certainly should pronounce an opinion in favor of cabbage. This crop yields a much greater return than that afforded by the Swedish turnip, and it is richer in nutritive matter. Cabbages are greedily eaten by sheep and cattle, and the butter of cows fed upon them is quite free from the disagreeable flavor which it so often possesses when the food of the animal is chiefly composed of turnips. If the cabbage admitted of storing, no more valuable crop could be cultivated as food for stock.

Mr. John M'Laren, of Inchture, Scotland, gives in the "Transactions of the Highland Agricultural Society of Scotland for 1857," a report on the feeding value of cabbage, which is highly favorable to that plant :—

On the 1st December, 1855 (says the reporter), two lots of Leicester wethers, bred on the farm, and previously fed alike, each lot containing ten sheep, were selected for the trial by competent judges, and weighed. Both lots were put into a field of well-sheltered old lea, having a division between them. All the food was cut and given them in troughs, three times a day. They had also a constant supply of hay in racks.

At the end of the trial, on the 1st of March, 1856, the sheep were all re-weighed, sent to the Edinburgh market, and sold same day, but in their separate lots. As I had no opportunity of getting the dead weights, I requested Mr. Swan, the salesman, to give his opinion on their respective qualities. This was to the effect that no difference existed in their market

value, but that the sheep fed on turnips would turn out the best quality of mutton, with most profit for the butcher. Both lots were sold at the same price, viz., 52s. 6d. During the three months of trial, we found that each lot consumed about the same weight of food—viz., 8 tons 13 cwt. 47 lb. of cabbage, being at the rate of $21\frac{1}{3}$ lbs. per day for each sheep, and 8 tons 10 cwt. 7 lb. Swedes, being at the rate of $20\frac{9}{10}$ lb. per day.

It will be seen, by referring to the table (see next page), that in this trial the Swede has proved of higher value for feeding purposes than the cabbage, making 11 st. 4 lb. of gain in weight, whilst the cabbage made 10 st. 9 lb. At the same time, 3 cwt. 40 lb. less food were consumed; and taking the mutton gained at 6d. per lb., the Swedes consumed become worth 9s. $3\frac{1}{4}$d. per ton, while the gain on the cabbage, at the same rate, makes them worth 8s. 7d. per ton. But from the great additional weight of the one crop grown over the other, the balance, at the prices, &c., mentioned, is in favor of the cabbage by £1 15s. $11\frac{3}{4}$d. per acre.

These results certainly speak strongly in favor of the cabbage; but the weight of the acreable crop of cabbages stated in the table appears to be unusually great. So heavy a crop is rarely obtained.

Furze (*Gorse, or Whins*).—Notwithstanding the natural historical knowledge of Goldsmith, his poetical description of the furze is far from accurate. This plant, instead of being "unprofitably gay," deserves to rank amongst the most valuable vegetables cultivated for the use of the domestic animals. It grows and flourishes under conditions which most injuriously affect almost every other kind of fodder and green crop. Prolonged drought in spring and early summer not unfrequently renders the hay crop a scanty one; while autumn and winter frosts change the nutriment of the mangels and turnips into decaying and unwholesome matter. Under such circumstances as these, the maintenance of cattle in good condition is very expensive, unless in places where a supply of furze is available. This plant is rather improved than otherwise by exposure to a temperature which would speedily destroy a mangel or a turnip; and, although it thrives best when abundantly supplied with rain, it can survive an exceedingly prolonged drought without sustaining much injury.

TABLE

SHOWING THE DIFFERENCE OF WEIGHT GROWN ON AN ACRE OF CABBAGE AND AN ACRE OF SWEDES, AND THE VALUE OF EACH FOR FEEDING.

No. of Sheep in each lot.	Kinds of Food.	Weight of Ten Sheep, 1st Dec., 1855.	Weight of Ten Sheep, 1st Mar., 1856.	Gain.	Value of Gain, taking Mutton at 6d. per lb.	Total Weight of Food consumed in Three Months by each lot.	Value of Food consumed per Ton.	Total Weight per Acre of each Crop.	Value of each Crop per Acre.	Extra Cost on each Crop per Acre.	Free Value of each Crop per Acre.	Balance in favor of Cabbage per Acre.
		st. lb.	st. lb.	st. lb.	£ s. d.	tons. cwt. lb.	s. d.	tons. cwt.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
.10	Cabbage	90 10	101 5	10 9	3 14 6	8 13 47	8 7	42 14	18 6 6	4 10 11	13 15 7	1 15 11¾
10	Swedes	89 3	100 7	11 4	3 19 0	8 10 7	9 3¼	26 12	12 6 7¼	0 7 0	11 19 7¼	

The furze is a member of the family *Leguminosæ*, which includes so many useful plants, such as, for example, the pea, the bean, and the clovers. There are three varieties of it met with in this country—namely, the common furze, *Ulex europæus*, the dwarf furze, *Ulex nanus*, and the Irish, or upright furze, *Ulex strictus*.

The common furze is a hardy shrub, and grows luxuriantly at an elevation far higher than the limits of cereal cultivation. It flourishes on any kind of soil which is moderately dry, and heavy crops may easily be raised on uplands almost incapable of producing grass. The dwarf furze is never cultivated, but as it grows at a still greater elevation, and on a poorer soil than the larger varieties, it might be profitably cultivated on very high uplands. The Irish furze yields a softer and less prickly food than the other kinds, but as it does not usually bear seed, and must therefore be propagated by cuttings, its cultivation has hitherto been limited to but a few localities.

The produce of an acre of furze appears to be at least equal to that of an acre of good meadow. The Rev. Mr. Townsend of Aghada, county of Cork—the most zealous and successful advocate for the cultivation of this plant—informed me that he had obtained so much as 14 tons per acre; a fact which proves that the furze is a plant which is well deserving of the attention of the farmer.

Furze is an excellent food for every kind of stock. Cattle, although they may at first appear not to relish its prickly shoots, soon acquire a fondness for it. I have known several instances of herds being fed almost if not entirely on the bruised plant, and to keep in good condition. The late Professor Murphy, of Cork, stated that on the farm of Mr. Boulger, near Mallow, thirty-five cows were fed on crushed furze, which they "devoured voraciously." Each animal received daily from four to six stones of the crushed plant, to which were added a little turnip pulp and a small quantity of oats. The milk and butter yielded by these cows were considered excellent. In a letter addressed

to me by a very intelligent feeder, Mr. John Walsh,* of Stedalt, county of Dublin, the following remarks in relation to this subject are made :—

I had lately an opportunity of seeing a herd of cattle of about sixty head, of which twenty had been fed with furze prepared with my machine for about six weeks before being put out to grass. The condition of these was so superior that I pointed out every one of them, one after the other, out of the herd. The owner of the cattle had made the same observation ; it was new to him but not to me.

Furze is seldom given to sheep or pigs, but I believe that it might with advantage enter into the dietary of those animals. Some of my friends who have lately tried it with pigs report favorably as to its effects. Horses partly fed upon this plant keep in good condition ; it is usually given to them cut merely into lengths of half an inch or an inch, but it would be better to give it to them finely bruised. A horse during the night will eat a much larger quantity of coarsely cut furze than of the well bruised article, because he is obliged to expend a great deal of muscular power in bruising the furze, and must, consequently. use an additional quantity of the food to make up for the corresponding waste of tissue.

Until quite recently, the chemistry of the furze was very little studied. The analysis of this plant made many years ago by Sprengel gave results which, in the present advanced condition of agricultural chemistry, are quite valueless. The late Professor Johnston merely determined its amount of water, organic matter, and ash. I believe I was the first to make a complete investigation into the composition of this plant according to the methods of modern chemical analysis. I made two examinations. The first was of shoots cut on the 25th April, 1860, on the lands of Mr. Walsh of Stedalt, near Balbriggan, in the county of Dublin. The shoots were, in great part, composed of that year's growth, with a small proportion of the

* This gentleman has invented an exceedingly simple but effective furze-bruiser, which I hope soon to see in general use.

shoots of the previous year. They were very moist, and their spines, or thorns, were rather soft. Their centesimal composition was as follows:—

Water	78·05
Nitrogenous, or flesh-forming principles	2·18
Fat-forming principles (oil, starch, sugar, gum, &c.)	8·20
Woody fibre	10·17
Mineral matter (ash)	1·40
	100·00

The second analysis was made of furze cut on the 15th August, 1862. The following were the results obtained:—

Water	72·00
Nitrogenous, or flesh-forming principles	3·21
Oil	1·18
Other fat-forming principles (starch, gum, &c.) ...	8·20
Woody fibre	13·33
Mineral matter	2·08
	100·00

The specimen was allowed to lie for a few days in a dry room, so that it lost a little water whilst in my possession, before it was subjected to analysis.

The sample cut in August contained a larger amount of nutriment than the specimen analysed in the spring; but its constituents appeared to be much less soluble in water, and therefore, less digestible.

Professor Blyth, of the Queen's College, Cork, has more recently made a very elaborate analysis of furze, grown in the county of Cork, which gave results still more favorable to the plant than those arrived at by me—probably because the specimens furnished to him were drier than mine.

ANALYSIS OF FRESH FURZE, BY DR. BLYTH.

100 parts contain :—

Matters readily soluble in water and easily digested.

*Albuminous, or flesh-forming compounds	1·68	
Fat and heat-producing, or respiratory elements, viz., sugar, gum, &c. &c.	7·83	
Ash	0·83	
Total matters soluble in water		10·34
*Containing nitrogen	0·265	

Matters insoluble in water.

Oil	2·14	
*Albuminous, or flesh-producing compounds	2·83	
Fat and heat-producing, or respiratory elements	1·00	
Woody fibre	28·80	
Ash	3·23	
Total matters insoluble in water		38·00
Water, expelled at 212...		51·50
		99·48
Total nitrogen in plant	0·71	
Total albuminous, or flesh-producing compounds	4·51	
Total respiratory, or heat and fat-producing compounds ...	8·83	
Total ash...	4·06	
The ash contains in 100 parts :—		
Potash	20·00	
Phosphoric acid	8·72	
*Containing nitrogen	0·445	

If the large per-centage of water be deducted, the dry, nutritive matters can then be more readily compared with the amount of the same substances in other feeding articles :—

Composition of 100 *parts of furze dried at* 212°. *Matters soluble in water in the dry furze.*

*Albuminous compounds	3·47	
Respiratory elements	16·15	
Ash	1·71	
Total matters soluble in water...		21.33
*Containing nitrogen	0·546	

Matters insoluble in water in the dry furze.

Oil	4·41	
*Albuminous compounds	5·84	
Respiratory elements	2·06	
Woody fibre	59·38	
Ash	6·66	
Total matters insoluble in water		78·35
		99·68
Total nitrogen in dry furze	1·46	
Total albuminous compounds	9·13	
Total respiratory elements	18·20	
Total ash	8·36	
*Containing nitrogen	0·917	

Composition of ash per cent.

Potash	20·00
Phosphoric Acid...	8·72

The results of these analyses show that dry furze contains an amount of nutriment equal to that found in dry grass. The nature of its composition resembles, as might be expected, that of its allied plants, vetches, &c., and therefore it exceeds the grasses in its amount of ready formed fatty matter.

SECTION IV.

STRAW AND HAY.

Straw.—At the present time, when the attention of the farmer is becoming more and more devoted to the production of meat, it is very desirable that his knowledge of the exact nutritive value of the various feeding substances should be more extensive than it is. No doubt, most feeders are practically acquainted with the relative value of corn and oil-cake—of Swedish turnips and white turnips; but their knowledge of the food equivalents of many other substances is still very defective. For example, every farmer is not aware that Indian corn

is a more economical food than beans for fattening cattle, and less so for beasts of burthen. Locust-beans, oat-dust, malt-combings, and many other articles, occasionally consumed by stock, have not, as yet, determinate places assigned to them in the feeder's scale of food equivalents.

The points involved in the economic feeding of stock are not quite so simple as some farmers, more especially those of the amateur class, appear to believe. There are many feeders who sell their half-finished cattle at a profit, and yet they cannot, without loss, convert their stock into those obese monsters which are so much admired at agricultural shows. The complete fattening of cattle is a losing business with some feeders, and a profitable one with others. Stall-feeding is a branch of rural economy which, perhaps more than any other, requires the combination of "science with practice;" yet how few feeders are there who have the slightest knowledge of the composition of food substances, or who are agreed as to the feeding value, absolute or relative, of even such well-known materials as oil-cake, straw, or oats! "It is thus seen how inexact are the equivalents which are understood to be established for the different foods used for the maintenance of the animals. It is equally plain, when we reflect on the different methods pursued for the preservation of the animals, that we are still far from having attained that perfection towards which our efforts tend. Visit one hundred farms, taken by chance in different parts of the country, and you will find in each, methods directly opposite—a totally peculiar manner of managing the stalls; you will see, in short, that the conditions of food, of treatment, and of hygiene, remain not understood in seven-eighths of rural farms."*

The straws of the cereal and leguminous plants are a striking illustration of the erroneous opinions and practices which prevail amongst agriculturists with respect to particular branches of their calling. The German farmers regard straw as the most valuable constituent of home-made fertilisers, and

* H. Le Docte, in *Journal de la Société Centrale d'Agriculture de Belgique.*

their leases in general prohibit their selling off the straw produced on their farms. Yet chemical analysis has clearly proved that the manurial value of straw is perfectly insignificant, and that, as a constituent of stable manure, it is chiefly useful as an absorbent of the liquid egesta of the animals littered upon it. As food for stock, straw was at one time regarded by our farmers as almost perfectly innutritious; some even went so far as to declare that it possessed no nutriment whatever, and even those who used it, did so more with the view of correcting the too watery nature of turnips, than with the expectation of its being assimilated to the animal body. Within the last few years, however, straw has been largely employed by several of the most intelligent and successful feeders in England, who report so favorably upon it as an economical feeding stuff, that it has risen considerably in the estimation of a large section of the agricultural public. Now, even without adopting the very high opinion which Mechi and Horsfall entertain relative to the nutritive power of straw, I am altogether disposed to disagree with those who affirm that its application should be restricted to manurial purposes. Unless under circumstances where there is an urgent demand for straw as litter, that article should be used as food for stock, for which purpose it will be found, if of good quality, and given in a proper state, a most economical kind of dry fodder—equal, if not superior to hay, when the prices of both articles are considered.

The composition of straw is very different from that of grain. The former contains no starch, but it includes an exceedingly high proportion of woody fibre; the latter is in great part composed of starch, and contains but an insignificant amount of woody fibre. Dr. Voelcker, the consulting chemist to the Royal Agricultural Society of England, and Dr. Anderson, chemist to the Highland and Agricultural Society of Scotland, have made a large number of analyses of the straws of the cereal and leguminous plants, the results of which are of the highest interest to the agriculturist. In the following tables the more important results of these investigations are given:—

ANALYSES OF STRAW, BY DR. VOELCKER.

	No. 1. Wheat, just ripe and well harvested.	No. 2. Wheat, over ripe.	No. 3. Barley, dead ripe.	No. 4. Barley, not too ripe.	No. 5. Oat, cut green.	No. 6. Oat, cut when fairly ripe.	No. 7. Oat, over ripe.	No. 8. Bean.	No. 9. Pea.	No. 10. Flax Chaff.
Water	13·33	9·17	15·20	17·50	16·00	16·00	16·00	19·40	16·02	14·60
Albumen, and other protein compounds:—										
a. Soluble in water	1·28	0·06	0·68	5·73	5·51	2·62	1·29	1·51	3·96	4·75
b. Insoluble in water	1·65	2·06	3·75		2·98	1·46	2·36	1·85	5·90	
Oil	1·74	0·65	1·36	1·17	1·57	1·05	1·25	1·02	2·34	2·82
Sugar, mucilage, extractive matters, &c. (soluble in water)	4·26	3·46	2·24	71·44	16·04	10·57	3·19	4·18	8·32	8·72
Digestible woody fibre and cellulose	19·40	82·26	5·97		26·34	30·17	27·75	2·75	17·74	18·56
Indigestible fibre, &c.	54·13		66·54		24·86	31·78	41·82	65·58	42·79	43·12
Inorganic matter:—										
a. Soluble ...	1·13	1·29	2·88	4·52	5·76	3·64	2·26	2·31	2·72	4·07
b. Insoluble ...	3·08	1·05	0·38		0·94	2·71	4·08	1·40	2·21	3·36
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

*** This table contains in a condensed form all the results of Voelcker's analyses of the straws which are given in his paper published in the *Journal of the Royal Agricultural Society of England*, vol. xxii., part 2. 1862.

Nos. 5, 6, and 7 were analysed shortly after being cut, when they contained a high proportion of water. They have, therefore, been calculated to contain 16 per cent. of moisture so as to arrive at accurate relative results.

ANALYSES OF STRAW, BY DR. ANDERSON.

	Wheat from East Lothian.		Wheat from Kent.	Barley from East Lothian.		Barley from Kent.	Sandy Oat from East Lothian.		Oat from Sea level, East Lothian	Oat from 850 feet above Sea level, East Lothian.	Oat from Mellhill, Inchture, Scotland.	Oat from Kent (White one side).
Water	10·62	10·93	11·15	11·44	11·15	11·10	11·70	10·95	12·60	11·28	11·70	10·55
Flesh-formers—												
Soluble ...	0·86	0·37	1·37	1·42	0·39	0·66	0·40	1·03	0·67	0·92	0·95	0·33
Insoluble ...	0·51	1·12	1·00	1·54	1·12	1·98	0·93	0·43	0·38	0·39	1·21	0·33
Oil	0·80	1·00	1·50	0·97	0·88	1·05	1·45	0·77	1·25	1·36	1·60	1·00
Respiratory elements—												
Soluble ...	2·68	6·68	5·26	3·22	6·11	4·56	10·12	6·90	7·16	7·42	12·01	6·23
Insoluble ...	44·88	36·43	38·79	35·56	38·38	27·95	33·52	34·77	24·28	29·55	23·35	30·95
Woody fibre ...	32·88	34·78	35·01	41·34	36·62	47·53	35·36	38·73	48·49	44·40	45·27	47·40
Ash	6·20	8·04	6·32	4·21	5·62	4·85	6·36	6·28	5·11	5·07	3·95	3·62
	99·43	99·35	100·40	99·70	100·27	99·68	99·84	99·86	99·94	100·39	100·14	100·41

*** This table is compiled from Dr. Anderson's paper in the *Transactions of the Highland and Agricultural Society of Scotland* for March, 1862.

Many very important conclusions are deducible from the facts recorded in these valuable tables. We learn from them that straw is more nutritious when it is cut in the ripe state than when it is permitted to over-ripen, and that *green* straw contains a far greater amount of nutriment than is found even in the ripe article. It appears also that the least nutritious kind of straw equals the best variety of turnips in its amount of flesh-forming principles, and greatly exceeds them in its proportion of fat-forming elements. We further learn that in general the different kinds of straw will be found to stand in the following order, the most nutritious occupying the highest, and the least nutritious the lowest place :—

1. Pea-haulm.
2. Oat-straw.
3. Bean-straw with the pods.
4. Barley-straw.
5. Wheat-straw.
6. Bean-stalks without the pods.

It is a matter to be regretted that we possess so little accurate knowledge of the chemical composition of the plants cultivated in Ireland. No doubt the analyses of English grown wheat, beans, mangels, and other plants, serve to give us a general idea of the nature of those vegetables when produced in this country. But this kind of information, though very important, must necessarily be defective, as differences in climate modify—often to a considerable extent—the composition of almost every vegetable. Thus, the results of Anderson's analyses prove Scotch oats to be superior, as a feeding stuff, to Scotch barley, whilst, according to Voelcker and the experience of most English feeders, the barley of parts of England is superior to its oats. It follows, then, that whilst the results of the analyses of straw, made by Voelcker and Anderson are of great interest to the Irish farmer, they would be still more important to him had the straw to which they relate been the produce of Irish soil. In order, therefore, to enable the Irish

farmer to form a correct estimate of the value of his straw, we should put him in possession of a more perfect knowledge of its composition than that which is derivable from the investigations to which I have referred. The straws of the cereals—which alone are used here to any extent—should be analysed as carefully and as frequently as those of Great Britain have been; and if such were done, I have no doubt but that the results would indicate a decided difference in composition between the produce of the two countries. Some time ago I entered upon what, at the time, I had intended should be a complete investigation into the composition of Irish straws; but which want of time prevented me from making more than a partial one. The results are given in the following tables:—

ANALYSES OF IRISH OAT-STRAW.

	No. 1. From Co. Wicklow.	Obtained in the Dublin Market.		
		No. 2.	No. 3.	No. 4.
Water	14·00	14·00	14·00	14·00
Flesh-forming principles—				
a. Soluble in water	4·08	2·02	2·04	1·46
b. Insoluble in water	2·09	3·16	3·00	2·23
Oil	1·84	1·40	1·26	1·00
Sugar, gum, and other fat-forming matters	13·79	12·67	10·18	11·16
Woody fibre	59·96	61·79	65·45	65·29
Mineral matter	4·24	4·96	4·07	4·86
	100·00	100·00	100·00	100·00

All the specimens of oats, the analyses of which are given in the preceding table, are assumed to contain 14 per cent. of water, in order the more correctly to compare their nutritive value. No. 1 contained 18·23 per cent. of water; No. 2, 12·90; No. 3, 12·74; and No. 4, 12·08. Oat straw, before its removal from the field, often contains nearly half its weight of water; but after being for some time stacked, the proportion of moisture rarely exceeds 14 per cent.

ANALYSES OF IRISH WHEAT-STRAW.

	No. 1. Green, changing to yellow. County Kildare.	No. 2. Ripe. County Dublin.	No. 3. Over Ripe. County Dublin.	Obtained in the Dublin Markets.		
				No. 4.	No. 5.	No. 6.
Water	13·00	13·15	12·14	10·88	11·22	12·12
Flesh-forming principles—						
a. Soluble in water	1·25	0·98	0·44	0·06	0·42	0·30
b. Insoluble in water	1·26	1·40	1·41	1·90	1·00	1·76
Oil	1·22	1·13	1·14	0·90	1·17	1·08
Sugar, gum, and other fat-forming matters	4·18	3·98	3·88	4·08	3·89	4·30
Woody fibre	75·84	76·17	77·76	78·67	79·18	77·15
Mineral matter (ash).	3·25	3·19	3·23	3·51	3·12	3·29
	100·00	100·00	100·00	100·00	100·00	100·00

The results of these analyses are somewhat different from those arrived at by Voelcker and Anderson. They show that properly harvested Irish oat and wheat straws are far more valuable than those of Scotland, and somewhat less nutritive than those produced in England. They also show that wheat-straw is allowed to over-ripen, by which a very large proportion of its nutritive principles is eliminated and altogether lost, and a considerable part of the remainder converted into an insoluble, and therefore less easily digestible state. Nor is there any advantage to the grain gained by allowing it to remain uncut after the upper portion of the stem has changed from a green to a yellowish color; on the contrary, it also loses a portion—often a very considerable one—of its nitrogenous, or flesh-forming constituents. It has been clearly proved that wheat cut when green, yields a greater amount of grain, and of a better quality too, than when it is allowed to ripen fully; yet, how often do we not see fields of wheat in this country allowed to remain unreaped for many days, and even weeks, after the crop has attained to its full development!

The oat-straw obtained in the Dublin Market proved less

valuable than the green straw which I selected myself from a field of oats; but the discrepancy between them was far less than between the nearly ripe wheat-straw and the straw of that plant purchased in Dublin. During visits which I have paid in harvest-time to the North of Ireland, I noticed that the oats were generally cut whilst green, whereas wheat was almost invariably left standing for at least a week after its perfect maturation, probably for the following reasons:—Firstly, because oats are more liable to shed their seed; secondly, because there is a greater breadth of that crop to be reaped, which necessitates an early beginning; and, lastly, because most farmers know that over-ripe oat-straw is worth but little for feeding purposes, as compared with the greenish-yellow article.

As compared with white turnips, the nutritive value of oat-straw stands very high, for whilst the former contains but little more than 1 per cent. of flesh-formers, and less than 5 per cent. of fat-formers, the latter includes about 4 per cent. of flesh-formers, and 13 per cent. of fat-formers. Again, whilst the amount of woody fibre in turnips is only about 3 per cent., that substance constitutes no less than 60 per cent. of oat-straw. In comparison with hay—taking into consideration the prices of both articles—oat-straw also stands high, as will be seen by comparing the following analyses of common meadow hay with that of properly harvested straw:—

	Meadow Hay.	Oat Straw.
Water	14·61	14·00
Flesh-forming constituents	8·44	6·17
Respiratory and fatty matters	43·63	15·63
Woody fibre	27·16	59·96
Mineral matter (ash)	6·16	4·24
	100·00	100·00

Woody fibre is as abundant a constituent of the straw of the cereals as starch is of their seeds, and if the two substances were equally digestible, straw would be a very valuable food—

superior even to the potato. At one time it was the general belief that woody fibre was incapable of contributing in the slightest degree to the nutrition of animals, but the results of recent investigations prove that it is, to a certain extent, digestible. In the summer of 1859 two German chemists, Stöckhardt and Sussdorf, made a series of experiments, with the view of ascertaining whether or not the cellulose* of the food of the sheep is assimilated by that animal. The results of this inquiry are of importance, seeing that they clearly prove that even the hardest kind of cellulose—*sclerogen*, in fact—is capable of being assimilated by the Ruminants. The animals selected were two wethers, aged respectively five and six years. They were fed—firstly, upon hay alone; secondly, upon hay and rye-straw; thirdly upon hay and the sawdust of poplar wood, which had been exhausted with lye (to induce the sheep to eat the sawdust, it was found necessary to mix through it some rye-bran and a little salt); fourthly, hay and pine-wood saw-dust, to which was added bran and salt; fifthly, spruce sawdust, bran and salt; sixthly, hay, pulp of linen rags (from the paper-maker), and bran. The experiments were carried on from July till November, excepting a short time, during which the animals were turned out on pasture-land, to recover from the injurious effects of the fifth series of experiments—produced probably by the resin of the spruce. The animals, together with their food, drink, and egesta, were weighed daily. The amount of cellulose in the food was determined, and the proportion of that substance in the egesta was also ascertained; and as there was a considerable discrepancy between the two amounts, it was evident that the difference represented the

* Cellulose is the term applied to the chemical substance which forms woody fibre. The latter is made up of very minute spindle-shaped tubes, In young and succulent plants these tubes are often lined with layers of soft cellulose. In many plants—such as trees—in a certain stage of development, the substance lining the cells is very hard, and is termed *lignin*, or *sclerogen*. This substance is merely a modification of cellulose; and both resemble in composition sugar and starch so closely that, by heating them with sulphuric acid, they may be converted into sugar.

weight of the cellulose assimilated by the animals. In this way it was ascertained that from 60 to 70 per cent. of the cellulose of hay, 40 to 60 per cent. of the cellulose of straw, 45 to 50 per cent. of the cellulose of the poplar wood, 30 to 40 per cent. of the cellulose of the pine, and 80 per cent. of the cellulose of the paper pulp was digested.

In stating the results of his analyses of the straws, Professor Voelcker sets down as "digestible" that portion of the cellulose which he found to be soluble in dilute acids and alkaline solutions; but he admits that the solvents in the stomach might dissolve a larger amount. The results of the experiments of Stöckhardt and Sussdorf prove that 80 per cent. of the cellulose. of paper (the altered fibre of flax) is assimilable, and it is, therefore, not unreasonable to infer that the cellulose of a more palatable substance than paper might be altogether digestible.

The facts which I have adduced clearly prove that the straws of the cereals possess a far higher nutritive power than is commonly ascribed to them; that when properly harvested they contain from 20 to 40 per cent. of undoubted nutriment; and lastly, that it is highly probable that their so-called indigestible woody fibre is to a great extent assimilable.

The composition of cellulose is nearly, if not quite, identical with that of starch, and it may therefore be assumed to be equal in nutritive power to that substance—that is, it will, if assimilated, be converted into four-tenths of its weight of fat. Now as cellulose forms from six-tenths to eight-tenths of the weight of straws, it is evident that if the whole of this substance were digestible, straws would be an exceedingly valuable fattening food. When straw in an unprepared state is consumed, there is no doubt but that a large proportion of its cellulose remains unappropriated—nay more, it is equally certain that the hard woody fibre protects, by enveloping them, the soluble and easily digestible constituents of the straw from the action of the *gastric juice.* I would, therefore, recommend that straw should be either cooked or fermented before being made use of; in either of these states its constituents are far more diges-

tible than when the straw is merely cut, or even when it is in the form of chaff. An excellent mode of treating straw is to reduce it to chaff, subject it to the action of steam, and mix it with roots and oil-cake or corn. Mr. Lawrence, of Cirencester, one of the most intelligent agriculturists in England, cooks his chaff, which he largely employs, in the following manner:—"We find that, taking a score of bullocks together fattening, they consume, per head per diem, 3 bushels of chaff mixed with just half a hundred-weight of pulped roots, exclusive of cake or corn; that is to say, rather more than 2 bushels of chaff are mixed with the roots, and given at two feeds, morning and evening, and the remainder is given with the cake, &c., at the middle day feed, thus:—We use the steaming apparatus of Stanley, of Peterborough, consisting of a boiler in the centre, in which the steam is generated, and which is connected by a pipe on the left hand with a large galvanised iron receptacle for steaming food for pigs, and on the right with a large wooden tub lined with copper, in which the cake, mixed with water, is made into a thick soup. Adjoining this is a slate tank of sufficient size to contain one feed for the entire lot of bullocks feeding. Into this tank is laid chaff, about one foot deep, upon which a few ladles of soup are thrown in a *boiling state;* this is thoroughly mixed with the chaff with a three-grained fork, and pressed down firm; and this process is repeated until the slate tank is full, when it is covered down for an hour or two before feeding time. The soup is then found entirely absorbed by the chaff, which has become softened, and prepared for ready digestion." A cheap plan is to mix the straw with sliced roots, moisten the mass with water, and allow it to remain until a slight fermentation has set in. This process effectually softens and disintegrates, so to speak, the woody fibre, and sets free the stores of nutritious matters which it envelopes. Some farmers who hold straw in high estimation, prefer giving it just as it comes from the field; they base this practice on the belief that Ruminants require a bulky and solid food, and that their digestive powers are quite sufficient to effect

the solution of all the useful constituents of the straw. It may be quite true that cattle, as asserted, can extract more nutriment out of straw than horses can, but that merely proves the greater power of their digestive organs. No doubt the food of the Ruminants should be bulky; but I am quite sure that cooked or fermented straw is sufficiently so to satisfy the desire of those animals for quantity in their food.

So far as I can learn, all the carefully conducted feeding experiments to test the value of straw which have been made, have yielded results highly favorable to that article. Mr. Blundell, in a paper on "The Use and Abuse of Straw," read before the Botley (Hampshire) Farmer's Club, states that in his experience he found straw to be more economical than its equivalent of roots or oil-cake, in the feeding of all kinds of cattle :—

> I find (says Mr. Blundell) that dairy cows, in the winter months, if fed on large quantities of roots, particularly mangels and carrots, will refuse to eat straw almost entirely, and become very lean ; but they will always eat a full portion of sweet, well-harvested straw, when they get a small and moderate allowance of roots, say, for an ordinary-sized cow, 15 lbs. of mangel three times per day, the roots being given whole, just in the state they come from the store heap. Again, calves and yearlings being fed with roots in the same way, will eat a large quantity of straw, and when they have been kept under cover I have had them in first-rate condition for many years past. Also, in fattening beasts, when they get a fair allowance of roots, say 65 to 70 lbs. per day, with from 3 to 4 lbs. of cake or meal in admixture, they will eat straw with great avidity, and do well upon it, and make a profit. It is, however, often the case that bullocks receive 100 lbs., or upwards, of roots per day, with a large quantity of cake or meal, often 10 or 12 lbs. per day ; they will not then look at straw, and are obliged to be fed with hay. The cost price of these quantities and kinds of food stands so high that the animals do not yield a profit; for although they may make meat a little faster, yet the proportionate increase is nothing compared to the increased cost of the feeding materials used.

Mr. Blundell gives us also the tabulated results of one of his experiments, which prove that by the use of straw there is to be obtained something more than manure by the feeding of stock :—

COST OF FEEDING AN OX PER WEEK WITH STRAW, ETC., ACCORDING TO MR. BLUNDELL.

	s.	*d.*
4 lbs. of oil-cake per day, or 38 lbs. per week, at £10 per ton	2	6
64 lbs. of roots ditto, or 4 cwt. ditto, at 13s. 4d. ditto...	2	8
20 lbs. of straw feeding, or 1¼ cwt. ditto, at 30s. ditto...	1	10½
20 lbs. of straw litter, or 1¼ cwt. ditto, at 15s. ditto ...	0	11
Attendance, &c., per week	0	1
	8	0½
Deduct value of manure, per week	1	3½
	6	9
Increased value of ox per week	10	0
Deduct cost of feeding	6	9
	3	3

If we now turn to the study of the composition of straw regarded from an economic point of view, we shall find that the theoretical deductions therefrom harmonise with the results of actual feeding experiments. Let us assume that 100 parts of oat-straw contain on an average—

1 part of oil,
4 parts of flesh-formers,
10 parts of sugar, gum, and other fat-formers, and
30 parts of digestible fibre ;

and if the price of the straw be 30s. per ton, we shall have at that cost the following quantities of digestible substances :—

ONE TON OF OAT-STRAW, AT 30s., CONTAINS :—

	lbs.
*Oil	22·4
Flesh-forming principles	89·6
Sugar, gum, and other fat-forming substances ...	224·0
Digestible fibre	672·0
	1,008·0
†Total amount of fat-formers, calculated as starch ...	952·0
Add flesh-formers	89·6
Total amount of nutritive matter	1,041·6

* One part of oil is equal to 2½ parts of starch—that is, 2½ parts of starch are expended in the production of 1 part of fat.

† No difference is here assumed between the nutritive value of sugar and starch.

We shall now compare this table with a similar one in relation to the composition of linseed cake, which will place the greater comparative value of straw in a clearer light.

A fair sample of linseed-cake contains, centesimally—

Flesh-formers	26
Oil	12
Gum, mucilage, sugar, &c.	34
Woody fibre	6

ONE TON OF LINSEED CAKE, AT £11, CONTAINS:—

	lbs.
Flesh-forming principles	582·4
Oil	268·8
Gum, sugar, and other fat-formers	761·6
Woody fibre	74·4
	1,687·2
Total amount of fat-formers, calculated as starch ...	1,508·0
Add flesh-formers	582·4
Total amount of nutriment	2,090·4

These comparisons are very instructive and important. We learn from them that we pay £11 for 2,000 lbs. of nutriment, when we purchase a ton of linseed-cake, whereas, when we invest 30s. in a ton of straw, we receive 1,000 lbs. of digestible aliment. It cannot be said that I have strained any points in favour of the straw; on the contrary, I believe that when that article is cut in proper season and well harvested, its composition will be found far superior to that detailed in the comparative analysis. It must be borne in mind, too, that I take no account of the 30 per cent. of the so-called indigestible woody fibre which straw contains, and which, I believe, is partly assimilable under ordinary circumstances, and could be rendered nearly altogether digestible by proper treatment; on the other hand, I have assumed that the woody fibre of the oil-cake is completely digestible, although I believe it is in reality less so than the fibre of straw.

It is an important point in the composition of oil-cakes, that they contain a large proportion of ready-formed fatty matters

which can, with but little alteration, be at once transmuted into animal fat. There are some individuals of the genus *Homo* to whose stomachs fat, *per se*, is intolerable; nevertheless, as a general rule, fatty substances exercise a favorable influence in the process of digestion, and, either in a separate state, or intimately commingled with other aliments, constitute a large proportion of the food of man. Digestion in the lower animals is, no doubt, similarly promoted by mixing with the aliments which are to be subjected to that process, a due proportion of oily or fatty matter. Straw is relatively deficient in the flesh-forming principles, and abounds in the fat-forming elements—of which, however, the most valuable, oil, is the least abundant. Now, if we add to straw a due proportion of some substance very rich in flesh-formers and oil, the compound will possess in nicely adjusted proportions all the elements of nutrition. Perhaps the best kind of food which we could employ for this purpose is linseed meal. It contains about 24 per cent. of flesh-formers, 35 per cent. of a very bland oil, and 24 per cent. of gum, sugar, and mucilage. Linseed-cake may be substituted for linseed-meal; but the meal, though its cost is 15 per cent. greater, is, I believe, rather the better article of the two. Its flesh-formers are more soluble, and its oil thrice more abundant and far more palatable than the same principles in most samples of oil-cake. An important point, too, is, that linseed, unlike linseed-cake, is not liable to adulteration. As linseed possesses laxative properties it cannot be largely employed; the addition, however, of bean-meal—the binding tendency of which is well known—to a diet partly composed of linseed will neutralise, so to speak, the relaxing influence of the oily seed. If oil-cakes be used as an adjunct to straw, rape-cake will be found more economical than linseed-cake. If it be free from mustard, well steamed, and flavored with a little treacle, or a small quantity of locust-beans, it will be readily consumed, and even relished, by dairy and fattening stock.

Hay.—There is no food substance more variable or more complex than hay, for under that term are included, not only

mixtures of grasses, but also of leguminous plants—clover, for example. The herbage of no two meadows is exactly alike ; and the composition of the meadow plants is so greatly modified by differences of climate, soil, and mode of culture, that we have nothing to excite our wonder in the extreme variability of hay.

The composition of the hay made from clover, lucerne, and various other kinds of artificial grasses, is shown in the table—which is based on the results of Way's analyses :—

COMPOSITION OF THE HAY OF ARTIFICIAL GRASSES.

	Flesh-forming Substances.	Fatty Matters.	Respiratory Substances.	Woody fibre.	Ash.	Water.
Trifolium pratense—red clover	18·79	3·06	37·06	16·46	7·97	16·6
Trifolium pratense perenne — Purple clover	15·98	3·41	35·35	21·63	6·96	,,
Trifolium incarnatum—Crimson clover	13·83	3·11	31·25	26·99	8·15	,,
Trifolium medium—Cow-grass	20·27	2·97	30·30	20·12	9·67	,,
Do., second specimen ...	15·64	3·98	41·38	15·70	6·64	,,
Trifolium procumbens—Hop trefoil...	17·07	3·89	36·55	18·88	6·94	,,
Trifolium repens—White trefoil...	15·63	3·65	33·37	22·11	8·57	,,
Vicia sativa — Common Vetch...	19·68	2·55	32·87	22·82	5·42	,,
Vicia sepium — Bush vetch	19·23	2·40	27·62	25·87	8·21	,,
Onobrychis sativa — Sainfoin	15·38	2·51	38·30	20·59	6·56	,,
Medicago sativa — Lucerne	10·63	2·30	33·47	28·51	8·42	,,
Medicago lupulina — Yellow clover	20·50	3·38	27·76	22·66	9·03	,,
Plantago lanceolata — Rib grass	11·91	3·06	33·58	27·56	7·23	,,
Poterium sanguisorba—Burnet	13·96	3·34	39·50	19·89	6·64	,,
Achillea millefolium—Millefoil	8·62	2·09	37·88	27·24	7·50	,,
Mean	15·81	3·18	34·42	22·47	7·59	16·6

Very many analyses of hay have been made by British and Continental chemists, the results of which are of great interest to the agriculturist. The composition of the natural and artificial grasses, which is shown in the tables given in pages 158-9 will, if we reduce their per-centage of water to 16, give us an approximation to the composition of hay. If the herbage, too, be sown in the proper time, and the hay-making process be skilfully conducted, there will be but little difference, except in the amount of water, between the plants in their fresh and dry state; but owing to inopportune wet weather, and carelessness in manipulation, excellent herbage is not unfrequently converted into inferior hay.

According to Dr. Voelcker, the average composition of meadow-hay, as deduced from the results of twenty-five analyses, is as follows :—

Water	14·61
Flesh-forming constituents	8·44
Respiratory and fatty matters	43·63
Woody fibre	27·16
Mineral matter (ash)	6·16
	100·00

Dr. Anderson's analysis of meadow-hay, one year old, and of inferior quality, gave the following results :—

Water	13·13
Flesh-forming matters	4·00
Non-nitrogenous substances	77·61
Mineral matter	5·26
	100·00

The results of the investigations of Way prove that the herbage of water-grass meadows is more nutritious than that of dry meadows—results perfectly harmonious with the experience of practical men.

It is a somewhat general belief, that the aftermath, or second cutting, is less nutritious than the first cutting; but there appears to be no chemical difference between the two crops, provided they be saved under equally favorable

conditions. According to Dr. Anderson, the composition of clover-hay of the second cutting is as follows :—

Water	16·84
Flesh-forming principles	13·52
Non-nitrogenous matters	64·43
Mineral matter (ash)	5·21
	100·00

I have already shown the importance of reaping in proper season—not less necessary is it to mow before the plants ripen fully, and even before they flower. The results of the experiments of Stöckhardt, Hellreigel, and Wolff, in relation to this point, are very interesting, and are well worthy of re-production here.

RESULTS OF STÖCKHARDT'S AND HELLREIGEL'S EXPERIMENTS.

	Stem.			Leaves.		
	Water in Fresh Plant.	Hay.		Water in Fresh Plant.	Hay.	
		Flesh-forming Matters.	Ash.		Flesh-forming Matters.	Ash.
Clover cut on the						
4th June, quite young...	82·80	13·16	9·71	83·50	27·17	9·42
23rd ,, ready for cutting	81·72	12·72	9·00	82·68	27·69	9·00
9th July, beginning to flower	82·41	12·40	6·12	77·77	15·83	10·46
29th July, full flower ...	78·30	9·28	4·63	70·80	19·20	9·58
21st August, ripe... ...	69·40	6·75	4·82	65·70	18·94	12·33

RESULTS OF WOLFF'S EXPERIMENT.

	Red Clover.				Alsike Clover.			
	Beginning to flower, 11th June.		Full flower, 25th June.		Beginning to flower, 23rd June.		Full flower, 29th June.	
	Fresh.	Hay.	Fresh.	Hay.	Fresh.	Hay.	Fresh.	Hay.
	pr. cent.	pr. cent.	pr. cent.	pr. cent.	pr. cent.	pr. cent.	pr. cent.	pr. cent.
Water	83·07	16·66	76·41	10·66	86·98	16·66	82·60	16·66
Ash	1·43	7·04	1·67	5·90	1·12	7·17	1·45	6·94
Woody fibre ...	4·24	20·87	8·88	37·37	3·79	24·26	5·11	24·47
Nutritive substances ...	11·26	55·43	13·04	46·07	8·11	51·91	10·84	51·93

During the operation of converting the grass—"natural" or "artificial"—into hay, there is more or less loss of nutritive matter sustained by fermentation, the dispersion of the smaller leaves by the wind, and other agencies. But this unavoidable loss is trivial when compared with the prodigious waste sustained, in Ireland at least, by allowing the hay to remain too long in cocks in the field. "Within the last three or four years," says Mr. Baldwin, of the Glasnevin Albert Model Farm, "we have made agricultural tours through twenty-five of the thirty-two counties of Ireland; and from careful consideration of the subject, and having in some instances used a tape-line and weighing-machine to assist our judgment, we have come to the conclusion that one-twentieth of the hay-crop of Ireland is permitted to rot in field-cocks. The portion on the ground, as well as that on the outside of the cocks, is too often only fit for manure. And the loss of aftermath, and of the subsequent year's crop (if hay or pasture), suffers to the extent of from six-pence to one shilling per acre. If we unite all these sources, the loss sustained annually in this country is something serious to contemplate. On an average, for all Ireland, it is not under 20 per cent., or a fifth of the actual value of the crop." This is a startling statement; but I do not believe it to be an exaggeration of the actual state of things.

Damaged Hay and Straw.—Damaged corn and potatoes, so much injured as to be unfit for human food, are generally given, and with apparently good results, to the inferior animals. The "meat manufacturing machines," as the edible varieties of the domesticated animals are now generally termed, are not very dainty in their choice of food; and vegetable substances which would excite the disgust of the lords of the creation are rendered nutritious and agreeable by being reorganised in the mechanisms of oxen, sheep, and pigs.

Now, although it is pretty generally known that musty corn and diseased potatoes form good feeding stuffs, it is not so patent whether or not the natural food of stock, such as hay and straw in a diseased state, is proper food for those animals.

This question is worthy of consideration. Firstly, I shall describe the nature of the diseases which most frequently affect fodder; these are, "mildew" and "mould." These diseases are produced by the ravages of minute and very low forms of vegetable life, termed by the botanists *epiphytical fungi*. The mildew (*Puccinia graminis*) generally attacks the grasses when they are growing, and is more frequently met with on rich and heavily manured soils. In localities where heavy night-fogs and dews are of common occurrence, this pest often destroys whole crops. On the other hand, in light, sandy, and well-drained soils, and in warm and dry districts, the mildew is a rare visitant. The "blue mould" (*Aspergillis glaucus*) attacks hay and straw in the stack or rick, and without any regard to their origin—no matter whether they were the produce of the wettest or the dryest, the warmest or the coldest of soils. The chief condition in the existence of the blue mould is excessive moisture. If the hay or straw be too green and succulent when put up, or if rain get at them in the rick, the mould is very likely to make its appearance, and the well-known odor termed *musty* will speedily be developed.

Neither the mildew nor the mould can, strictly speaking, be regarded as parasites, such as, for example, the flax-dodder, which feeds upon the healthy juices of the plant to which it is attached. It appears to me that the tissues and juices of the fodder-plants decay *first*, and then the mould or the mildew appears and feeds upon the decomposing matter. Now, as these vegetables belong to a poisonous class of fungi, it is more than probable that they convert the decomposing substance of the straw or hay into unwholesome, if not poisonous matter; and it is not unlikely but that the disagreeable odor which they evolve is designed by nature as a sign to the lower animals not to partake of mouldy food. There is no doubt but that most animals will instinctively reject fodder in this state; and the question arises, ought this odour to be destroyed or disguised, in order to induce the animals to eat the damaged stuff? The experience of most feeders who have largely consumed mouldy

provender is, that although cattle may be induced to eat it, they never thrive upon such stuff if it form a heavy item in their diet The reason of this is obvious. The nitrogenous portion of the straw is that which is chiefly assimilated by the fungi. And as this constituent is the one which contributes to the formation of muscle, and is naturally extremely deficient in straw and hay—more particularly the former—it follows that the animals fed upon mouldy fodder cannot elaborate it into lean flesh (muscle).

In the case of young stock, mouldy fodder is altogether inadmissible, for these animals require abundance of flesh-forming materials—precisely those which the fungi almost completely remove from the diseased fodder.

As large quantities of mouldy or mildewed provender are at the present moment to be found in many farmsteads, and as they are unsaleable, and must therefore be made use of in some way at home, it is well to consider the best way to dispose of them. In the case of straw, the greater portion will be required for litter, and if the whole of the damaged article can be disposed of in this way so much the better. If, however, there is more than is necessary for the bedding of the stock, it may be used in conjunction with sound fodder, but always in a cooked state. The greater part, if not the whole, of the diseased nitrogenous part of the straw is soluble in warm water, so that if the fodder be well steamed the poisonous matter will be eliminated to such an extent as to leave the article almost as wholesome as good straw, but not so nutritious. The straw cleansed in this way will be very deficient in flesh-forming, though not in fat-forming power, and this fact should be duly considered when the other items of the animal's food are being weighed out. Beans, malt-combs, and linseed-cake are rich in muscle-forming principles, and are consequently suitable adjuncts to damaged fodder; but the latter should never constitute the staple food, or be given unmixed with some sweet provender.

When the fodder is considerably damaged it becomes,

after steaming, nearly as tasteless as sawdust. To this kind of stuff the addition of a small amount of some flavorous material is very useful. For damaged hay, Mr. Bowick recommends the following mixture :—

Fenugreek (powdered)	112 parts.
Pimento	4 „
Aniseed	4 „
Caraways	4 „
Cummin	2 „

A pinch of this compound will render agreeably-flavored the most insipid kinds of fodder.

Mr. Bowick states that he had fed large numbers of bullocks on damaged hay, flavored with this compound, and that their health was not thereby injured in the slightest degree.

SECTION V.

ROOTS AND TUBERS.

THE important part which the so-called root crops play in the modern systems of agriculture, has secured for them a large share of the attention of the chemist, so that our knowledge of their composition and relative nutritive value is very extensive. As compared with most other articles of food, the roots, as they are popularly called, of potatoes, turnips, mangels, carrots, and such like plants, contain a high proportion of water, and are not very nutritious; indeed, with the exception of the potato, none of them contain 20 per cent. of solid matter, and some not more than five per cent. They are, however, easily produced in great quantities, which compensates for their low nutritive value. I shall consider each of the more important roots separately.

The Turnip.—There are numerous varieties of this plant, which differ from each other in the relative proportions and

total amount of their constituents, and even in different individuals of the same variety there is considerable variation in composition; hence the difficulty which has been felt by those who have endeavored to assign to this plant its relative nutritive value. From the average results of a great number of experiments, conducted both in the laboratory and the feeding-house, it is concluded that turnips are the most inferior roots produced in the field. The Swedish turnips are the most valuable kind: they contain a higher proportion of solid matter than the other varieties, and they are firmer and store better. The average composition of five varieties of turnips, as deduced from the results of the analyses of Anderson and Voelcker, is shown in the following table:—

ANALYSES OF TURNIPS.

	Swedish Turnip.	White Globe.	Aberdeen Yellows.	Purpletop Yellows.	Norfolk Bell.
Water	89·460	90·430	90·578	91·200	92·280
Albuminous, or flesh-forming substances...	1·443	1·143	1·802	1·117	1·737
Non-nitrogenous, or fat-forming substances (fat, gum, sugar, &c.)	5·932	5·457	4·622	4·436	2·962
Woody fibre	2·542	2·342	2·349	2·607	2·000
Mineral matter (ash) ...	0·623	0·628	0·649	0·640	1·021
	100·000	100·000	100·000	100·000	100·000

The *Greystone Turnip* is a variety which has only quite recently been introduced. It is stated to be an uncommonly productive crop, usually yielding returns from 30 to 50 per cent. greater than those obtained from other varieties of the turnip. The composition of the Greystone turnip appears to be inferior, so that probably it is not, after all, a more economical plant than the ordinary kinds of turnips.

DR. ANDERSON'S ANALYSIS OF THE GREYSTONE TURNIP.

	No. 1. Grown on Clay.	No. 2. Grown on Sand.
Water...	93·84	94·12
Oil	0·26	0·34
Soluble albuminous matters ...	0·35	0·56
Insoluble ditto	0·20	0·18
Soluble respiratory matters ...	2·99	2·32
Insoluble ditto (chiefly fibre) ...	1·73	1·85
Ash	0·63	0·63
	100·00	100·00

It was at one time the fashion—not yet become quite obsolete—to regard the proportion of nitrogen in the turnip as the measure of the nutritive value of the bulb; but the fallacy of this opinion has been shown by several late investigators, and more particularly by the results of one of the numerous series of feeding experiments conducted by Mr. Lawes. Many bulbs exceedingly rich in nitrogen are very deficient in nutritive power—partly from a deficiency in the other elements of nutrition—partly because most of their nitrogen is in so low a degree of elaboration as to be incapable of assimilation by animals. The value of a food-substance does not merely depend upon the amount and the relative proportion of its constituents, but also, and to a very great extent, upon their easy assimilability. There is but little doubt that the nutritive matters contained in the Swedish turnip when the bulb is fresh are very crude. By storing, certain chemical changes take place in the bulb, which render it more nutritious and palatable. A large proportion of the non-nitrogenous matters exist in the fresh root as pectin; but this substance, if the bulb be preserved for a couple of months, becomes in great part converted into sugar, which is one of the most palatable and fattening ingredients of cattle-food. By storing, too, the bulbs lose a portion of their excessive amount of water, and become less bulky, which is unquestionably a desideratum. These facts suggest the necessity for cultivating the earlier varieties of the turnip, for it may be fairly doubted if a late-grown crop, left for consumption in the field, ever,

even under the most favorable circumstances, attains its perfect development. At the same time it must not be forgotten that turnips *fully matured* in the field rather deteriorate than otherwise after a few weeks' storage.

Many agriculturists consider that there is a strict relation between the specific gravity, or comparative weight of the bulb, and its nutritive value; others believe that a very large turnip must necessarily be inferior in feeding qualities to a small one; whilst not a few maintain that neither its size nor its specific gravity is an indication of its feeding qualities. Dr. Anderson, who has specially investigated a portion of this subject, states that "the specific gravity of the whole turnip cannot be accepted as indicating its real nutritive value, the proportion of air in the cells being the determining element in such results; that there is no constant relation between the specific gravity of, and the nitrogen compounds in, the bulb; and that such relation does exist between the specific gravity of the expressed juice and the nitrogen compounds and solid constituents." Dr. Anderson allows, however, that the best varieties of the turnip have the highest specific gravity; which admission—coupled with the fact admitted by all experimenters that the heavy roots store best—lead me to adopt the opinions of those who consider great specific gravity as one of the favorable indications of its nutritive value. With respect to size, I prefer bulbs of moderate dimensions; the monsters that win the prizes at our agricultural shows—and which, in general, are *forced*—are inferior in feeding qualities, are always *spongy*, and almost invariably rot when stored.

The composition of the turnip is influenced not only by the nature of the soil on which it is grown, but also by that of the manure applied to it. The most reliable authorities are agreed that turnips raised on Peruvian guano are watery, and do not keep well; but that with a mixture of Peruvian guano and superphosphate of lime, with phospho-guano, or with farmyard manure supplemented with a moderate amount of guano, the most nutritious and firm bulbs are produced.

Turnip-tops have been analysed by Voelcker, with the following results :—

ONE HUNDRED PARTS CONTAIN—

	White.	Swedish.
Water	91·284	88·367
Nitrogen compounds	2·456	2·087
Non-nitrogenous matters (gum, sugar, &c.)	0·648	1·612
Ditto, as woody fibre	4·092	5·638
Mineral matter...	1·520	2·296
	100·00	100·000

These figures apparently show that the tops of turnips are more valuable than their bulbs ; but, in the absence of any feeding experiments made to determine the point, we believe they are less so, as a very large proportion of the solid matter in the tops of turnips is in too low a degree of elaboration to be assimilable. Their high proportions of nitrogen and mineral matter constitute them, however, a very useful manure—nearly twice as valuable as the bulbs ; this fact should be borne in mind when turnips are sold off the land.

The Mangel-wurtzel is one of the most valuable of our green crops. Its root is more nutritious than the turnip, occupying a position in the scale of food equivalents midway between that bulb and the parsnip. Mangels, when fresh, possess a somewhat acrid taste, and act as a laxative when given to stock ; but after a few months' storing they become sweet and palatable, and their *scouring* property completely disappears.

Although the mangel is one of the most nutritious articles of food which can be given to cattle, yet it is stated on the best authority that sheep do not thrive upon it. Voelcker, who has investigated this subject, informs us that a lot of sheep which he fed on a limited quantity of hay and an unlimited quantity of mangels, did not, during a period of four months, increase in weight, whilst another lot of sheep supplied with a small quantity of hay, and Swedish turnips *ad libitum* increased

on an average $2\frac{1}{2}$ lbs. weekly. I believe the experience of the greater number of feeders agrees with the results of Dr. Voelcker's experiment.

The chemistry of the mangel-wurtzel has been thoroughly studied by Way and Ogston, Fromberg, Wolff, Anderson, and Voelcker. According to the last-named chemist, its average composition is as follows:—

Water	87·78
Flesh-forming matters	1·54
Sugar	6·10
Gum, pectin, &c.	2·50
Woody fibre	1·12
Mineral matter (ash)	0·96
	100·00

It is difficult to accurately determine by a comparative trial the relative feeding properties of mangels and turnips, for the former are only in a fit state to be given to the animals when the latter are deteriorating. However, by comparing the composition of the two substances, and the results obtained from numerous feeding experiments, it would appear, that on the average 75 lbs. weight of mangels are equal to 100 lbs. weight of turnips. Of the different varieties of the mangel the long yellow appears to be the most nutritious, and the long red the least so.

The leaves of the mangel—some of which are occasionally pulled and used for feeding purposes, during the growth of the bulb—are an excellent feeding substance: their composition indicates a nutritive value but little inferior to that of the root; but as their constituents cannot be in a highly elaborated condition, it is probable they are not more than equal to half their weight of the bulbs.

One *questio vexata* of the many which at present occupy the attention of the agricultural world is, whether or not the leaves of mangels may be removed with advantage during the latter part of the development of the plants. This practice

prevailed rather extensively a few years since, but latterly it has fallen somewhat into disuse.

Those who adopt this plan urge, as its advantages, that a large quantity of food is obtained at a time when it is urgently needed, and that instead of the removal of the leaves exercising an injurious influence on the development of the roots, the latter are actually increased in size.

In 1859 an experimental investigation was carried out at the Glasnevin Model Farm, with the view of throwing new light on the question. The outside leaves were very gradually removed on different occasions—from the 12th August to the 15th October. In this way five tons of leaves per statute acre were removed, and subsequently made use of for feeding purposes. The experiment was conducted on a field of four acres, of which the produce of 12 drills, each 200 yards in length, was left untouched. The result was that the produce of the roots of the untouched plants was only 40 tons 8 cwt. 6 qrs. per acre, whilst the roots of the plants which had been partly denuded of their leaves weighed at the rate of 45 tons 1 cwt. This experiment afforded results which are apparently favorable to the practice of stripping the leaves; but it is to be regretted that it was not rendered more complete by an analysis of the roots, as a great bulk of roots does not necessarily imply a great weight of dry food, and it is just possible, though not very probable, that the roots of the stripped mangels contained a larger proportion of water than those of the untouched plants.

The results of the experiments of Buckman, and of Professor Wolff, of the Royal Agricultural College at Hohenheim, are at direct variance with those obtained at Glasnevin. Both of these experimenters found that the removal of the leaves occasioned a diminution in the produce of the roots to the amount of 20 per cent. Nor was this the only loss, for it was found by the German professor that the roots of the untouched plants possessed a far higher nutritive value than those of the stripped mangels.

When doctors differ, who is to decide? Here we have high authorities in the agricultural world at direct variance on a matter of fact. The names of Buckman and Wolff are a sufficient guarantee that the experimental results which they announce are trustworthy, and I can testify, from observation, that no field experiments could be more carefully conducted than those carried out at the Albert Model Farm. We can only, then, under the circumstances, admit that both Mr. Boyle, on the one side, and Professors Buckman and Wolff on the other, are correct in their statements of fact; but as it is evident both cannot be right in the general inferences therefrom, it is desirable that the subject should be still further investigated, and the truth be placed beyond doubt. It is a question which appears so simple that one is at a loss to account for the discrepant opinions in relation to it which prevail. "Let nothing induce the growers," says Mr. Paget, in a paper on the cultivation of the mangel, "to strip the leaves from the plant before taking up the root. A series of careful experiments has convinced me that by so doing we borrow food at a most usurious interest." "Although," says Mr. Boyle, "the practice of stripping has been followed for many years on the farm without any perceptible injury to the crop, these results, showing so considerable an addition to the crop from taking off the leaves, were hardly anticipated." It certainly does appear somewhat at variance with our notion of the functions of the leaves of plants, that their partial removal could possibly cause an increase in the weight of the roots; but granting such to be the fact, it is not altogether *theoretically* inexplicable. We know that highly nitrogenous manure has a tendency to increase the development of the leaves of turnips at the *expense* of the roots. Gardeners, too, not unfrequently remove some of the buds from their fruit trees, lest the excessive development of foliage should retard or check the *growth* of the fruit. *Theoretically* an excessive development of the leaves of the mangel may be inimical to the growth of the root. Probably, too, it may be urged, the outer leaves, which

soon become partially disorganised and incapable of elaborating mineral matter into vegetable products, prevent the access of light to the more vigorous inner leaves. In conclusion, I may say of this subject that it is worthy of further elucidation; and I would suggest to my readers, and more especially to the managers of the various model farms, the desirability of fully testing the matter.

The *White Beet* is a congener of the mangel. It is largely grown on the continent as a sugar-producing plant, but is seldom cultivated in these countries. It produces about 15 tons of roots per acre, and its roots on the average contain—

Water	83·0
Sugar	10·0
Flesh-formers	2·5
Fat-formers...	1·5
Fibre	2·0
Ash	1·0
	100·0

This plant is deserving of more extensive growth in Great Britain.

The *Parsnip* is, after the potato, the most valuable of roots. It differs from the turnip and the mangel in containing a high proportion of starch, and but little sugar; and its flesh-forming constituents are largely made up of casein, instead of, as in the case of the turnip, albumen.

The average composition of the parsnip is as follows:—

Water	82·00
Flesh-forming principles	1·30
Fat-formers (starch, sugar, &c.)	7·75
Woody fibre	8·00
Mineral matter (ash)	0·95
	100·00

The parsnip is extensively grown in many foreign countries, on account of its valuable feeding properties. As a field-crop it is but little cultivated in Great Britain, and its use is—if we

except the table—almost restricted to pigs. Its food equivalent is about double that of the turnip; that is, one pound of parsnips is equal to two pounds of turnips.

The *Carrot* bears a close resemblance to the parsnip, from which, however, it differs, containing no starch, and being somewhat inferior in nutritive value. According to Voelcker, its average composition is as follows:—

Water	88·50
Flesh-formers	0·60
Fat-formers (including woody fibre)	10·18
Mineral matter (ash)	0·72
	100·00

As carrots contain a high proportion of fat-forming matters, and a low per-centage of flesh-forming substances, they are better adapted for fattening purposes. Dairy stock greedily eat them; and they are given with great advantage to horses out of condition.

Kohl-Rabi.—This plant, though early introduced into the agriculture of these countries, has made but little progress in the estimation of the farmer. It belongs to the order and genus which include the turnip, but differs widely from that plant in its mode of growth. Its bulb—which is formed by an enormous development of the overground stem—is, according to some authorities, less liable than the turnip to injury from frost. It is subject to no diseases, save anbury and clubbing; and, owing to its position above the soil, it can be readily eaten off by sheep. The bulbs store better than Swedes, and, according to some farmers, keep even better than mangels. With respect to the flavor of this bulb, there is some difference of opinion. Professor Wilson, of Edinburgh, quotes several eminent feeders to prove that "whether in the fold for sheep, in the yard for cattle, or in the stables for horses, it will generally be preferred to the other descriptions of home-grown keep." Mr. Baldwin, on the contrary, states that although good food for sheep, it is too hard-fleshed for old

ewes, and that carrots are better food for horses, and Swedish turnips for cattle.

An accurately conducted comparative trial to test the nutritive value of the Kohl-rabi, was conducted at the Glasnevin Model Farm, under the direction of Mr. Baldwin. The experiment was commenced in January, 1863. Four oxen were selected, and divided into two lots. Nos. 1 and 2 (Lot 1) were fed on Kohl-rabi, oil-cake, and hay, and Nos. 3 and 4 (Lot 2) on Swedish turnips, oil-cake, and hay. As the animals supplied with the Kohl-rabi did not appear to relish it, and as it was desirable to gradually accustom them to the change of food, the experiment did not really commence till the 12th January. On that date the weights of the animals were as follows:—

		cwt.	st.			cwt.	st.
Lot 1.	No. 1.	10	1	Lot 2.	No. 3.	7	5
	No. 2.	7	4		No 4.	10	2
		17	5			17	7

The lots, therefore, counterpoised each other pretty fairly. From the 12th to the 28th January they received the following quantities of food per diem:—

		1.	2.	3.	4.
Roots	stones	7½	6	6	7½
Oil cake	pounds	4½	3	3	4½
Hay	pounds	10½	10½	10½	10½

The animals fed upon the Kohl-rabi evinced from the first a disinclination to it, but they nevertheless ate it before their meal of oil-cake was supplied to them. On the morning of the 28th January they were put upon the dietary shown in the table, and which induced them to eat the Kohl-rabi more quickly.

		1.	2.	3.	4.
At 6.30 a.m.	Roots, Stones ...	3	2½	2½	3½
	Cake, lbs.	1½	1	1	1
At 12.30 a.m.	Roots, Stones ...	3	2½	2½	3½
	Cake, lbs.	1½	1	1	1
At 6.30 p.m.	Roots, Stones ...	3	2½	2½	3½
	Cake, lbs.	1½	1	1	1
At 9.30 p.m.	Hay, lbs.	7	7	7	7

On the 11th February the cattle were again weighed, when their increase was found to be as follows :—

	Weight on Jan. 12. cwt.	st.	Weight on Feb. 11. cwt.	st.	Increase in 30 days. st.
1 } Lot 2, fed on Kohl- ...	10	1	10	4	3
2 } rabi, &c.... ...	7	4	7	6	2
Total					5
3 } Lot 2, fed on Swedes, ...	7	5	8	3	6
4 } &c.	10	2	10	7¼	5½
Total					11½

The results of this experiment show that the animals fed upon Swedish turnips, hay, and oil-cake, increased in weight at a rate more than 100 per cent. greater than the lot supplied with equal quantities of Kohl-rabi, hay, and oil-cake. The superiority of the Swedish turnips was rendered more evident by the results of subsequent experiments. Nos. 1 and 4 were not tried after the 11th February; but Nos. 2 and 3 were kept under experiment. No. 2 was put on Swedes, and No. 3 on mangel-wurtzel, and after an interval of a fortnight No. 2 had increased much more than they had done on Kohl-rabi.

Specimens of the Kohl-rabi and Swedish turnips employed in this experiment were submitted to me for analysis by Mr. Baldwin, and yielded the following results :—

	Kohl-rabi.	Swedish Turnip.
Water	87·62	88·84
Nitrogenous, or flesh-forming principles	2·24	1·66
Non-nitrogenous, or fat-forming principles	7·78	6·07
Woody fibre	1·34	2·73
Mineral matter (ash)	1.22	0·70
	100·00	100·00

These results show a slight superiority of the Kohl-rabi over the Swedish turnip; the great difference in their nutritive power, as shown by Mr. Baldwin's experimental results, must

therefore be due to the superior flavor and digestibility of the turnip.

Dr. Anderson's analysis of Kohl-rabi afforded results more favorable to the highly nutritive character assigned by some feeders to that bulb than those arrived at by me. The bulbs, it should however be remarked, were grown, no doubt with great care, by Messrs. Lawson and Son, the well-known seedsmen :—

ANALYSIS OF KOHL-RABI, BY DR. ANDERSON.

	Bulbs.	Tops.
Water	86·74	86·68
Flesh-forming principles	2·75	2·37
Fat-forming principles	8·62	8·29
Woody fibre	0·77	1·21
Mineral matter	1·12	1·45
	100·00	100·00

The *Radish* is a plant which deserves a place amongst our field crops, though hitherto its cultivation has been restricted to the garden. At one time its leaves were boiled and eaten, but in these latter days they are subjected to neither of these processes. The root, however, in its raw state, is, as every one is aware, considered one of the dainties of the table.

Many of those who devote themselves to the important study of dietetics, consider the use of raw vegetables to be objectionable; but be their objections groundless, or the reverse, it is certain that a vegetable which, like the radish, may be eaten raw with apparently good results, cannot be otherwise than a good article of food when cooked. I once tried the experiment of eating matured radishes, not as a salad, but cooked like any other boiled vegetable, and I must say that I found their flavor rather agreeable than otherwise. Boiled radishes—roots and tops—form excellent feeding for pigs. How could it be otherwise? for what is good for the family of man must surely be a luxury to the swine tribe. I have known horses to eat radishes greedily, and I am certain that they would prove acceptable to all the animals of the farm. But it

may be asked, why it is that I recommend the use of radishes as food for stock, when there are already so many more nutritious roots at our disposal—turnips, mangels, and potatoes. Simply for this reason:—Between the departure of the roots and the advent of the grasses, there is a kind of interregnum.* Now we want a good tuberous, bulbous, or tap-rooted plant to fill up this interregnum. Such a plant we have in the radish. The root is certainly a small one, but then it grows so rapidly that a good supply can be had within thirty days from the sowing of the seed, and a crop can be matured before the time for sowing turnips. Two crops may be easily obtained from land under potatoes—one before the tops cover the ground, the other after the tubers have been dug out. The yield of radishes, judging from the produce in the garden, would be at least six tons of roots and three tons of tops. I would suggest, then, that the radish should at once get a fair chance as a stolen crop. If it succeed as such, it will not be the first gift of the gardener to the husbandman. Was not the mangel-wurtzel once known only as the produce of the garden?

The composition of the radish indicates a nutritive value less than that of the white turnip. I have analysed both the root and the tops, and obtained the following results:—

ANALYSIS OF THE RADISH.

	Root.	Tops.
Water	95·09	94·30
Flesh-forming principles	0·52	0·75
Fat-formers (starch, gum, fat, &c.) ...	1·06	1·16
Woody fibre	2·22	2·36
Mineral matter (ash)	1·11	1·43
	100·00	100·00

The *Jerusalem Artichoke* has long been cultivated as a field-crop on the Continent, and in certain localities the breadth

* Unless when Kohl-rabi is cultivated, for the bulbs of this plant may be preserved in good condition up to June. I have advocated the cultivation of the radish as a food crop in the "Agricultural Review" for 1861.

O 2

occupied by it is very considerable. The French term the tuberous root of this plant *poitre de terre*, or *topin ambour;* and although they expose it for sale in the markets, it is not much relished by our lively neighbours, who are so remarkable for their *cuisiniere*. As food for cattle, however, the French agricultural writers state it to be excellent. It is much relished by horses, dairy cows, and pigs; store horned-stock also eat it when seasoned with a little salt, and appear to enjoy it amazingly when permitted to pull up the roots from the soil. The green tops are also given to sheep and cattle, and, it is stated, are readily eaten by those animals.

The Jerusalem artichoke (*Helianthus Tuberoses*) differs from its half namesake, the common artichoke, and resembles the potato in being valuable chiefly for its tubers. It is perennial, and attains on the Continent a height varying from 7 to 10 feet. In this country its dimensions are less. The stem is erect, thick, coarse, and covered with hairs. It is a native of Mexico, and although introduced 200 years ago into Europe, it can hardly be said to be acclimatised, since it very seldom flowers, and never develops seed. The plant is therefore propagated by cuttings from its tubers, each containing one or two eyes; or if the tubers be very small, which is often the case, a whole one is planted. The tubers possess great vitality, and remain in the ground during the most severe frosts, without sustaining the slightest injury. For this reason it is usual to devote a corner of the garden to the cultivation of the Jerusalem artichoke; for, no matter how completely the crop may appear to have been removed from the soil, portions of the tubers will remain and shoot up into plants during the following season. This peculiarity of the plant it is likely may prove an obstacle to its having a place assigned to it in the rotation system.

The question now presents itself—What are the peculiar advantages which the crop possesses which should commend it to the notice of the British farmer? I shall try to answer the question.

1st. No green crop (except furze) can be grown in so great a variety of soils; except marshy or wet lands, there is no soil in which it refuses to grow.

2nd. It does not suffer from disease, is very little affected by the ravages of insects, is completely beyond the influence of cold, and may remain either above or below ground for a long time without undergoing any injurious changes in composition.

3rd. It gives a good return, when we consider that it requires very little manure, and but little labor in its management.

At Bechelbronn, the farm of the celebrated Boussingault, the average yield is nearly eleven tons per acre, but occasionally over fourteen tons is obtained. Donoil, a farmer of Bailiere, in the department of Haut-loire, states that he fed sheep exclusively on the tops and tubers of this plant, and that he estimated his profits at £23 per hectare (£9 3s. 4d. per acre). The soil was very inferior. Donoil terms it third-rate, and it does not appear to have been manured even once during the fifteen years it was under Jerusalem artichoke. I fear our artificial manure manufacturers will hardly look with a favorable eye on the advent of a crop into our agriculture which can get on so well without the intervention of any fertilising agents. Indeed, several of the French writers state that little or no manure is necessary for this plant. But this can hardly be the case; for it is evident that a crop which, according to Way and Ogston, removes 35 lbs. of mineral matter per ton from the soil, or three times as much potash as turnips do, must certainly be greatly benefited by the application of manure. And I have no doubt but that the Jerusalem artichoke, if well manured and grown in moderately fertile soil, would produce a much heavier crop than our Continental neighbors appear to get from it.

4th. The Jerusalem artichoke may be cultivated with advantage in places where ordinary root-crops either fail or thrive badly. In such cases the ground should be permanently devoted to this crop. Kade gives an instance where a piece of indifferent ground had for thirty-three years produced heavy

crops of this plant, although during that time neither manure nor labor had been applied to it. In Ireland the potato has been grown under similar circumstances.

The nutritive constituents of tubers of the Jerusalem artichoke bear a close resemblance in every respect, save one, to those of the potato. Both contain about 75 per cent. of water, about 2 per cent. of flesh-forming substances, and 20 per cent. of non-nitrogenous, or fat-forming and heat-giving elements. In one respect there is a great difference—namely, that sugar makes up from 8 to 12 per cent. of the Jerusalem artichoke, whilst there is but a small proportion of that substance in the potato.

The large quantity of sugar contained in this root is no doubt the cause of its remarkable keeping properties in winter, and it also readily accounts for the avidity with which most of the domesticated animals eat it.

On the whole, then, I think that the facts I have brought forward relative to the advantages which the Jerusalem artichoke presents as a farm crop, justify the recommendation that it should get a fair trial from the British farmer, who is now so much interested in the production of suitable forage for stock.

COMPOSITION OF (DRY) JERUSALEM ARTICHOKE.

Albuminous matters	4·6
Fatty matters	0·4
Starch, gum, &c.	19·8
Sugar	69·5
Fibre and ash	5·7
	100·0

The *Potato*, regarded from every point of view, is by far the most important of the plants which are cultivated for the sake of their roots. Its tubers form the chief—almost sole—pabulum of many millions of men, enter more or less into the dietary of most civilised peoples, and constitute a large proportion of the food of the domesticated animals. The great importance of this plant, arising from its enormous consump-

tion, has caused its composition to be very minutely studied by many British, Continental, and American chemists. With respect to its nutritive properties, the least favorable results were obtained by the American chemists, Hardy and Henry, and the most by the European chemists.

The flesh-forming principles vary from 1 per cent., as found by Hardy, to 2·41 per cent., the mean results of the analyses of Krocker and Horsford. The proportion of starch in different varieties of the potato also varies, but not to the same degree as the nitrogenous principles. In new potatoes, only 5 per cent. has been found; in ash-leaved kidneys, 9·50 per cent.; and in different kinds of cups, from 15 to 24 per cent. The amount of starch is also influenced by the soil, the manure, the climate, and the various other conditions under which the plant is developed. The proportion of starch increases during the growth, and diminishes during the storage of the tubers.

Dr. Anderson is the most recent investigator into the composition of the potato; the chief results of his inquiries are given in the following table :—

ANALYSIS OF THE POTATO BY DR. ANDERSON.

	Regents.	Dalma-hoys.	Skerry-blues.	White Rocks.	Orkney Reds.	Flukes.
Water	76·32	75·91	76·60	75·93	78·57	74·41
Starch	12·21	12·58	11·79	12·77	10·85	12·55
Sugar, &c.	2·75	2·93	3·09	2·17	2·78	2·89
Flesh-formers, soluble ...	2·16	2·10	1·90	1·88	1·48	1·98
Flesh-formers, insoluble...	0·21	0·15	0·16	0·24	0·21	0·20
Fibre	5·53	5·21	5·41	5·55	5·93	6·71
Ash	0·88	0·81	0·94	1·04	0·98	0·98
	100·06	99·69	99·89	99·58	100·80	99·72

The potato is relatively deficient in flesh-forming matters, and contains the respiratory elements in exceedingly high proportions; hence it is well adapted for fattening purposes, and in this respect is equal to double its weight of the best kind of turnips. When used as food for man, it should be supplemented by some more fatty or nitrogenous substance—such,

for example, as flesh, oatmeal, or peas. Buttermilk, a fluid which is rich in nitrogen, is an excellent supplement to potatoes, and compensates to a great extent for the deficiency of those tubers in muscle-forming matters. If, then, the potato is destined to retain its place as the "national esculent" of the Irish, I trust their national beverage may be—so far at least as the masses of the people are concerned—buttermilk, and *not* whiskey.

Potatoes so far diseased as to be unsuited for use as food for man, may be given with advantage to stock. They may be used either in a raw or uncooked state, but the latter is the preferable form. Sheep do not like them at first, but on being deprived of turnips they acquire a taste for them; on a daily allowance, composed of 1 lb. of oil-cake or corn, and an unlimited quantity of potatoes, they fatten rapidly. Cattle thrive well on a diet composed of equal parts of turnips and diseased potatoes, and do not require oil-cake. The evening feed of horses may advantageously be composed of potatoes and turnips. If raw, the potatoes should be given in a very limited quantity—four or five pounds; in the cooked state, however, they may be given in abundance, but the animals should not, after their meal, be permitted to drink water for some hours. As a feeding substance, diseased potatoes, unless they be very much injured, are equal to twice their weight of white turnips; it is certain that they do not injure the health or impair the condition of the animals which feed upon them.

SECTION VI.

SEEDS.

In seeds the elements of nutrition exist not only in the most highly elaborated, but also in the most concentrated state; hence their nutritive value is greater than that of any other class of food substances.

Wheat Grain is the most valuable of seeds, as it contains, in admirably adjusted proportions, the bone, the fat, and the muscle-forming principles. In the form of bread, it has been, not inaptly, termed the "staff of life," for no other grain is so well adapted, *per se*, for the sustenance of man; and many millions of human beings subsist almost exclusively on it. The lower animals are in general fed upon the grain of oats, of barley, and of the leguminous plants, and the use of wheat is almost completely restricted to the human family.

Wheat grain, by the processes of grinding and sifting, is resolvable into two distinct parts—bran and flour. In twenty-four analyses made by Boussingault, the proportion of the bran was from 13·2 to 38·5 per cent., and that of the flour from 61·5 to 86·8 per cent. The floury part is of very complex structure; it includes starch, gluten, albumen, oil, gum, gummo-gelatinous matter, sugar,* and various saline matters. The gluten and albumen constitute the nitrogenous, or flesh-forming principles of flour, and make up from 16 to 20 per cent. of that substance; the non-nitrogenous, or fat-forming elements, such as starch and gum, form from 74 to 82 per cent. According to Payen, the proportion of gluten diminishes towards the centre of the seed, from which it follows that the part of the grain nearest the husk is the most nutritious—so far at least as muscle-making is concerned. The desire on the part of the public for very white bread has led to the *fine* dressing of Wheat-grain, and consequently to the separation from that substance of a very large proportion of one of its most nutritious constituents. Crude gluten may be obtained by kneading the dough of flour in a muslin bag under a small current of water; the starch, or fecula, and the gum, are carried away by the water, and the gluten in an impure form remains as an elastic viscous substance, which on drying becomes hard and brittle. It is to the gluten of flour that its

* According to some chemists, sugar does not exist in ripe grain, but is produced in it, during the process of analysis, by the action of the re-agents employed and the influence of the air.

property of panification, or bread-making, is due. On the addition of a ferment, a portion of the starch is converted into sugar and carbonic acid gas, and the latter causes the gluten to expand into the little cells, or vesicles, which confer upon baked bread its light, spongy texture.

ANALYSES OF WHEAT.

	1. Whole Grain.	2. Flour.	3. Bran.	4. Husk.
Water	15·00	14·0	13	13·9
Flesh-formers	12·00	11·0	14	14·9
Fat-formers	68·50	73·5	55	55·8
Woody fibre	2·75	0·7	12	9·7
Mineral matter	1·75	0·8	6	5·7
	100·00	100·0	100	100·0

Nos. 1, 2, *and* 3.—*The mean results of a great number of analyses.* *No.* 4.—*By* MILLON.

Over-ripening of Grain.—The final act of vegetation is the production of seed, after the performance of which function many plants, having accomplished their destined purpose, perish. The grasses (which include the cereals) are *annuals*, or plants which have but a year's existence, consequently their development ceases so soon as they have produced their seed. When wheat, oats, and the other cereals, attain to this final point in their growth, the circulation of their sap ceases, their color changes from green to yellow, and they undergo certain changes which destroy their power of assimilating mineral matter, and consequently render them no longer capable of increasing their weight.

The proper time for cutting wheat and the other cereals is immediately after their grain has been fully matured. When the green color of the straw just below the ears changes to yellow, the grain, be it ripe or unripe at the time, cannot afterwards be more fully developed. This is rendered impossible in consequence of the disorganisation of the upper part of the stem—indicated by, but not the result of, its altered hue—

which cuts off the supply of sap to the ears, and the latter do not possess the power of absorbing nutriment from the air.

When the vital processes which are incessantly going on in the growing plants are brought to a close, the purely chemical forces come into operation. If the seed be perfectly matured and allowed to remain ungathered, it is attacked in wet weather by the oxygen of the air, a portion of its carbon is burned off, some of its starch is converted into sugar, and in extreme cases it germinates and becomes *malty*. But not only is the seed liable to injury from the elements; it is also exposed to the ravages of the feathered tribe, and no matter how well a field of corn may be watched, or how great the number of *scarecrows* erected in it, there is always a certain diurnal loss, occasioned by the ravages of birds.

It is not only necessary that ripe corn should be cut as soon as possible, but it is sometimes desirable to reap it before it becomes fully matured. When the grain is intended for consumption as food, the less bran it contains the better. Now the bran, as is well known, forms the integument, or covering of the vital constituents of the seed; and it is the last part of the organ to be perfected. The growth of the seed for several days before its perfect development, is confined to the *testa* or covering. Now as this is the least valuable part of the article, its increase is matter of but little moment; and when it is excessive it renders the grain less valuable in the eyes of the miller. That the cutting of the grain before it is perfectly ripe is attended with a good result, is clearly proved by the results of an experiment recorded in Johnston's "Agricultural Chemistry." A crop of wheat was selected; one-third was cut twenty days before it was ripe; another third ten days afterwards; and the remaining portion when its grain had been fully matured. The relative produce in grain of the three portions taken, as stated above, was as 1, 1·325, and 1·260. The following table exhibits the relative proportions of their constituents:—

	In 100 parts of the grain cut at 20 days.	10 days.	Dead ripe.
Flour...	74·7	79·1	72·2
Sharps	7·2	5·5	11·0
Bran...	17·5	13·2	16·0
	99·4	97·8	99·2
The flour contained gluten ...	9·3	9·9	9·6

The results of this experiment, and of the general experience of intelligent growers, show that grain cut a week or ten days before it is perfectly ripe contains more flour, and of a better quality, too, than is found in either ripe or very unripe seed. But this is not the only advantage, for the straw of the green, or rather of the greenish-yellow corn, is fully twice as valuable for feeding purposes as that of the over-ripe cereals. There is an extraordinary decrease in the amount of the albuminous constituents of the stems of the cereals during the last two or three weeks of their maturation, and as there is not a corresponding increase of those materials in the seed, they must be evolved in some form or other from the plants.

There can be only one object attained by allowing the seed to fully ripen itself, and that is the insurance of its more perfect adaptability to the purpose of reproduction. When the *testa* is thick it best protects the germ of the future plant enclosed in it from the ordinary atmospheric influences until it is placed under the proper conditions for its germination.

Wheat, a costly food.—It occasionally happens that the wheat harvest is so abundant, that many feeders give large quantities of this grain to their stock. Now, as Indian corn is at least 25 per cent. cheaper than wheat, even when the price of the latter is at its *minimum*, I believe that it is always more economical to sell the wheat raised on the farm, and to purchase with the proceeds of its sale an equivalent of Indian corn, which is a more fattening kind of food.

Bran is, with perhaps the exception of malt-dust, the most nutritious of the refuse portions of grains. It is usually given to horses, and owing to its high proportion of nitrogen, is,

perhaps, better expended in the bodies of those hard-working animals, than in those of pigs and cows—animals that occasionally come in for a share of this valuable feeding-stuff. It should be borne in mind that bran commonly acts as a slight laxative, and that it is less digestible than flour, a large portion of it usually passing through the animal's body unchanged. This drawback to the use of bran may be obviated by either cooking or fermenting the article, or by combining it with beans or some other kind of binding food.

AVERAGE ANALYSES OF GRAIN.

	Barley.	Bere.	Oats.	Oat-meal.	Indian Corn.	Rice.	Rye (Irish).	Buck-wheat.
Water	16·0	14·25	14·0	13·00	14·5	14·0	16·0	14·19
Flesh-formers	10·5	10·10	11·5	16·00	10·0	5·3	9·0	8·58
Fat-formers	67·0	64·60	64·5	68·00	69·0	78·5	66·0	51·91
Woody fibre	3·5	9·03	7·0	1·75	5·0	2·5	8·0	23·12
Mineral matter	3·0	2·02	3·0	1·25	1·5	0·7	1·0	2·20
	100·0	100·00	100·0	100·00	100·0	100·0	100·0	100·00

Barley is inferior in composition to wheat. As a feeding stuff, the English farmers assign to it a higher, and the Scotch farmers a lower, place than oats, which, perhaps, merely proves that in Scotland the oat thrives better than the barley, and in England the barley better than the oat. Barley-meal is extensively used by the English feeders, and with excellent results. Where *barley-dust* can be obtained it is a far cheaper feeding stuff than the meal. Barley husks should never be given to animals unless in a cooked or fermented state.

Oat Grain is, perhaps, the most valuable of the concentrated foods which are given to fattening stock. When it is cheap it will be found a more economical feeding stuff than linseed-cake, and, unlike that substance, can be used without the fear of adulteration. Oats are equal to wheat in their amount of flesh-forming matters; but their very high proportion of indigestible woody fibre detracts from their nutritive value. Oat-meal is more nutritious than wheat-meal; and oat-flour,

especially if finely dressed, greatly excels wheat-flour in its nutrimental properties, because, unlike the latter, the finer it is the greater is its amount of flesh-formers. Bread made of oat-flour is very heavy, and is far less palatable than the bread of wheat. Oat-meal has been found to contain nearly 20 per cent. of nitrogenous matters. The white oat is more nutritious than the black, and the greatest amount of aliment is found in the grain which has not been allowed to over-ripen in the field. Oat husk is very inferior to the bran of wheat. Toppings are seldom worth the price at which they are sold.

Indian Corn has been highly extolled as a fattening food for stock, and its chemical composition would seem to justify the high opinion which practical men have formed of its relative nutritive value. In the United States, the feeding of horses on Indian corn and hay has been found very successful; but in these countries oats will be found a more economical food. For fattening purposes Indian corn appears exceedingly well adapted, as it contains more ready-formed fat—4·5 per cent.—than is found in most of the other grains, and, on an average, 70 per cent. of starch. Pigs thrive well on this grain. The Galatz round yellow grain is somewhat superior to the American flat yellow seed.

Rye is not extensively cultivated in this country, but on the Continent it is raised in large quantities. In the north of Europe it forms a considerable proportion of the food of both man and the domesticated animals. In Holland it is commonly consumed by horses, but in England there has always been a prejudice against the use of this grain as food for the equine tribe. It has been highly recommended for dairy stock, five pounds of rye-meal, with a sufficiency of cut straw, constituting, it is stated, a dietary on which cows yield a maximum supply of milk. Irish-grown rye contains less starch, and more flesh-formers and oil, than the Black Sea grain.

Rice, although it forms the chief pabulum of nearly one-third of the human family, is the least nutritious of the common food grains. Rice-dust, an article obtained in cleaning rice

for European consumption, is said to promote the flow of milk when given to cows. It is sold in large quantities in Liverpool, where, according to Voelcker, it often commands a higher price than it is worth.

Buckwheat is chiefly used as a food for game and poultry.

Malted Corn.—During a late session of Parliament a Bill was passed to exempt from duty malt intended to be used as food for cattle. As feeders may now become their own maltsters, it may be of some use to them to have here a *résumé* of this Bill :—

1. Any person giving security and taking out a licence may make malt in a malt-house approved by the Excise for the purpose; and all malt so made and mixed with linseed-cake or linseed-meal as directed, shall be free from duty.

2. The security required is a bond to Her Majesty, with sureties to the satisfaction of the Excise, not to take from any such malt-house any malt except duly mixed with material prescribed by the Act.

3. The malt-house must be properly named upon its door.

4. All malt made in it shall be deposited in a store-room, and shall be conveyed to and from the room upon such notice as the officer of Excise shall appoint.

5. The maltster shall provide secure rooms in his malt-house, to be approved in writing by the supervisor, for grinding the malt made by him in such malt-house, and mixing and storing the same when mixed; and all such rooms shall be properly secured and kept locked by the proper officer of Excise.

6. All malt before removal from the malt-house shall be ground and thoroughly mixed with one-tenth part at least of its weight of ground linseed-cake or linseed-meal, and ground to such a degree of fineness and in such manner as the commissioners shall approve, and mixed together in a quantity not less than forty bushels at a time in the presence of an officer of Excise.

7. The maltster shall keep account of the quantity of all malt mixed as aforesaid which he shall from time to time send out or deliver from his malt-house, with the dates and addresses of the person for whom such mixed malt shall be so sent or delivered.

8. If any person shall attempt to separate any malt from any material with which the same shall have been mixed as aforesaid, or shall use this malt for the brewing of beer or distilling of spirits, he shall forfeit the sum of £200.

9 and 10. The penalties of existing Acts are recited.

11. This Act shall continue and be in force for five years.

Some samples of malt and barley examined in May, 1865, by Dr. Voelcker for the Central Anti-Malt Tax Association, afforded the following results :—

	Barley marked No. 1.	Malt marked No. 5.	No. 7.	No. 9.	No. 14.	No. 16.
Moisture	11·76	8·72	7·43	7·76	8·35	7·06
Sugar	3·75	4·29	5·48	7·85	9·46	9·86
Starch and dextrine ...	70·40	71·03	69·70	67·57	67·53	67·67
*Albuminous compounds (flesh-forming matters)	7·75	8·44	8·81	9·37	8·60	8·31
Woody fibre (cellular)	4·46	5·22	6·38	5·38	4·14	5·11
Mineral matter (ash) ...	1·88	2·30	2·20	2·07	1·92	1·99
	100·00	100·00	100·00	100·00	100·00	100·00
* Containing nitrogen ...	1·24	1·35	1·41	1·50	1·38	1·33

A great deal has been said and written in favor of malt as a feeding stuff, but I greatly doubt its alleged decided superiority over barley; and until the results of accurately conducted comparative experiments made with those articles incontestably prove that superiority, I think it is somewhat a waste of nutriment to convert barley into malt for feeding purposes. The gentlemen who verbally, or in writing, refer so favorably to malt, acknowledge, with one or two exceptions, that their experience of the article is limited. Mr. John Hudson, of Brandon, states that he made a comparative experiment, the results of which proved the superiority of malt. But, in fact, the only properly-conducted experiments to determine the relative values of malt and barley were those made some years ago by Dr. Thompson, of Glasgow, by the direction of the Government, and those recently performed by Mr. Lawes, both producing results unfavorable to the malt. The issue of Dr. Thompson's investigations proved that milch cows fed on barley yielded more milk and butter than when supplied with an equal weight of malt.

I do not deny the probability that malt, owing to its agreeable flavor and easy solubility, may be a somewhat better

feeding stuff than barley; and that, weight for weight, it may produce a somewhat greater increase in the weight of the animals fed upon it: but although a pound-weight of malt may be better than a pound-weight of barley, I am quite satisfied that a pound's worth of barley will put up more flesh than a pound's worth of malt. Barley-seeds consist of water, starch, nitrogenous substances—such as gluten and albumen—fatty substances, and saline matter. The amount of starch is considerable, being sometimes about 70 per cent. In the process of malting (which is simply the germination of the seed under peculiar conditions), a portion of the starch is converted into sugar and gum, the grain increases in size and becomes friable when dried, and the internal structure of the seed is completely broken up. During these changes a partial decomposition of the solid matter of the seeds takes place, and a large amount of nutriment is dissipated, chiefly in the form of carbonic acid gas. From the results of the experience of the maltster, and of special experiments made by scientific men, it would appear that a ton of barley will produce only 16 cwt. of malt. Allowance must, however, be made for the difference between the amount of water contained in barley and in malt, the latter being much drier. According to Mr. E. Holden, the centesimal loss sustained in malting may be stated thus:—

Water	6·00
Organic matter	12·52
Saline matter	0·48
	100·00

Dr. Thompson* sets down the loss of nutriment (exclusive of that occasioned by kiln-drying), as follows:—

Carried off by the steep	1·5
Dissipated on the floor	3·0
Roots separated by cleaning	3·0
Waste...	0·5
	8·0

* Report to Government on feeding cattle with Malt, 1844.

We may say, then, that by the malting of barley we lose at least $2\frac{1}{2}$ cwt. of solid nutriment out of every ton of the article, and this loss falls heaviest on the nitrogenous, or flesh-forming constituents of the grain. When there are added to this loss the expense of carting the grain to and from the malt-house, and the maltster's charge for operating upon it (I presume in this case that the feeder is not his own maltster), it will be found that two tons of malt will cost the farmer nearly as much as three tons of barley; and he will then have to solve the problem—*Whether or not malt is* 40 *or* 50 *per cent. more valuable as a feeding-stuff than barley.*

The difference in value between barley and malt is generally 14s. per barrel; but it is sometimes more or less, according to the supply and demand. Barley, well malted, will lose on the average 25 per cent. of its weight, the loss depending, to some extent, upon the degree to which the process is carried, and on the germinating properties of the barley. Barley malted for roasters ought not to lose more than 21 per cent. of its original weight—53 lbs. to the barrel. The heavier the barley the less it loses in malting; a barrel of 224 lbs., and value from 15s. to 16s., ought to produce a barrel of malt of 196 lbs., value 29s. to 30s.

If we deduct from the cost of a barrel of malt the amount of duty at present levyable upon it, the price of the article will be still nearly 50 per cent. greater than that of an equal weight of barley. The cheaper barley is the greater will be the relative cost of malt. The maltster's charge for converting a barrel of barley into malt is about 4s.; so that if the price of the grain be so low as 12s. per barrel, which it sometimes is, the cost of malting it would amount to 33 per cent. of its price. Then, the diminution in the weight of, and the cost of carting the grain, must be taken into account; and when the whole expense attendant upon the process of malting is ascertained, it will be found that I have not exaggerated in stating that a ton of malt costs as much as a ton and a half of barley.

If the consumer of malt germinate the seeds himself, he

may probably, if he require large quantities of the article, produce it at a somewhat cheaper rate than if he bought it from the maltster; but few persons who have the slightest knowledge of the vexatious restrictions of the Inland Revenue authorities would be likely to place his premises under the *espionage* of an excise officer.

As the superiority of malt over barley (if such be really the case) must be chiefly due to the looseness of its texture, which allows the juices of the stomach to act readily upon it, barley in a cooked state might be found quite as nutritious: it would not be fair to institute comparisons between dense hard barley-seeds and the easily soluble malted grains. During the cooking of barley a portion of the starch is changed into sugar, but in this case with only an inappreciable waste of nutriment. When the cooking process is continued for a few hours, a considerable amount of sugar is formed, and the barley acquires a very sweet flavor.

When the malt for cattle question was under discussion, I made a little experiment in relation to it, the results of which are perhaps of sufficient interest to mention:—Two pounds weight of barley-meal were moistened with warm water; after standing for three hours more water was added, and sufficient heat applied to cause the fluid to boil. After fifteen minutes' ebullition, a few ounces of the pasty-like mass which was produced were removed, thoroughly dried, and on being submitted to analysis yielded six per cent. of sugar. The addition of a small quantity of malt to barley undergoing the process of cooking will rapidly convert the starch into sugar.

Barley is naturally a well-flavored grain, and all kinds of stock eat it with avidity. It may be rendered still more agreeable if properly cooked, and this process will, by disintegrating its hard, fibrous structure, set free its stores of nutriment. I incline strongly to the opinion that barley, when well boiled, is almost, if not quite, as digestible as malt.

A serious disadvantage in the use of malt is, that it must be consumed, it is said, in combination with 10 per cent. of

its weight of linseed-meal or cake. Now, malt is a very laxative food, and so is linseed; and if the diet of stock were largely made up of these articles the animals would, sooner or later, suffer from diarrhœa. In such case, then, the addition of bean-meal, or of some other binding food, would become necessary, and the compound of malt, linseed, and bean-meal thereby formed would certainly prove anything but an economical diet.

Malt Combs.—I should mention that a portion of the nutriment which the barley loses in malting passes into the radicles, or young roots, which project from the seeds, and are technically known by the term "combs," "combings," or "dust." At present these combs are separated from the malt, but if the latter be intended for feeding purposes this separation is unnecessary, and in such case the barley will not be so much deteriorated. The combs, which constitute about 4 per cent. of the weight of the malt, are sometimes employed as a feeding stuff. I have made an analysis of malt-combings for the County of Kildare Agricultural Society, and have obtained the following results:—

100 PARTS CONTAINED—

Water	8·42
*Flesh-forming (albuminous) substances	21·50
Digestible fat-forming substances (starch, sugar, gum, &c.)	53·47
Indigestible woody fibre	8·57
† Saline matter (ash)	8·04
	100·00
* Yielding nitrogen	3·44
† Containing potash	1·35
,, phosphoric acid	1.74

This article was sold as a manure at £3 6s. per ton—a sum for which it was not good value; but as a feeding substance it was probably worth £4 or £5 per ton. Its composition indicates a high nutritive power; but it is probable that its nitrogenous matters are partly in a low degree of elaboration, which greatly detracts from its alimental value.

In conclusion, then, I would urge the following points upon the attention of the farmer :—

1st. Before using malt for feeding purposes, wait until you learn the general results of the experience of other farmers with that article. The manufacture of malt for feeding purposes is rapidly on the decline, instead of, as had been anticipated, on the increase.

2nd. Should you experiment with barley and malt, use equal money's worth of each, and employ the barley in a cooked state.

3rd. Use malt-combings as a feeding stuff, and not as a manure. They are good value for at least £3 10s. per ton.

4th. Bear in mind that a ton of barley contains more saline matter than an equal weight of malt; consequently, that stock fed upon barley will produce a manure richer in potash and phosphates than those supplied with malt.

Leguminous Seeds.—The seeds of the bean, of the pea, and of several other leguminous plants, are largely made use of as food for both man and the domesticated animals. They all closely resemble each other in composition, but in that respect differ considerably from the grains of the *Cerealiæ*, for whilst the latter contain on an average 12 per cent. of flesh-formers, beans and peas contain 24 per cent. The flesh-forming constituent of the leguminous seeds is not gluten, as in the grain of the cereals, but a substance termed *legumin*, which so closely resembles the cheesy matter of milk that it has also received the name of *vegetable casein.* Indeed, the Chinese make a factitious cheese out of peas, which it is difficult to discriminate from the article of animal origin.

Beans are used as fattening food for cattle, for which purpose they should be ground into meal, as otherwise a large proportion of their substance would pass through the animal's body unchanged. It is not good economy to give a fattening bullock more than 3 or 4 lbs. weight per diem; a larger proportion is apt to induce constipation. The very small proportion of ready-formed fat, the moderate amount of starch,

and the exceedingly high per-centage of flesh-formers which beans contain, prove that they are better adapted as food for beasts of burthen than for the fattening of stock. Oats, Indian corn, or oil-cake, will be found to produce a greater increase of meat than equal money's worth of beans or peas, and I would therefore recommend the restriction of leguminous seeds, under ordinary circumstances, to horses and bulls. It has been stated, on good authority, that when oats are given whole to horses, a large proportion passes unchanged through the animal's body, but that on the addition of beans, the oats are thoroughly digested.

COMPOSITION OF LEGUMINOUS SEEDS.

	Common Beans.	Foreign Beans.	Peas.	Lentils.	Winter Tares (foreign).
Water	13·0	14·5	14·0	13·0	15·5
Flesh-formers	25·5	23·0	23·5	24·0	26·5
Fat-formers	48·5	48·7	50·0	50·5	47·5
Woody fibre	10·0	10·0	10·0	10·0	9·0
Mineral matter	3·0	3·8	2·5	2·5	1·5
	100·00	100·00	100·00	100·0	100·0

Oil Seeds.—The seeds of a great variety of plants, such as the flax, hemp, rape, mustard, cotton, and sunflower, are exceedingly rich in oil, some of them containing nearly half their weight of that substance. Of these oil-seeds there are many which might with advantage be employed as fattening food, although one only—linseed—has come into general use for that purpose.

Rape-seeds closely resemble linseeds in composition, but they are considerably cheaper. They contain an acrid substance, but the large proportion of oil with which it is associated almost completely disguises its unpleasant flavor.

Linseed is one of the most valuable kinds of food which could be given to fattening animals. Its exceedingly high proportion of ready-formed fatty matter, the great comparative

solubility of its constituents, and its mild and agreeable flavor, constitute it an article superior to linseed cake. The laxative properties of linseed are very decided; it should therefore be given only in moderate quantities. As peas and beans exercise, as I have already stated, a relaxing influence upon the bowels, a mixture of linseed and peas or beans would be an excellent compound, the laxative influence of the one being corrected by the binding tendency of the other. Linseed being one of the most concentrated feeding stuffs in use, it will be found an excellent addition to bulky food, such as chaff and turnips. Linseed oil has been used as a fattening food, but there is nothing to be gained by expressing seeds for the purpose of using their oil as a feeding material. When hay is scarce, and straw abundant, the latter may be made almost as nutritious as the former by mixing it with linseed, and steaming the compound. A stone of linseed and two cwt. of oat-straw chaff, when properly cooked, constitute a most economical and nutritious food.

Mr. Horne, who experimented with linseed two or three years ago, obtained results highly favorable to the nutritive value of that article. Six bullocks were selected, and each animal placed in a separate box. They were fed with cut roots—at first Swedes, then mangels and Swedes, and lastly, mangels alone: in addition, there were supplied to each 6 lbs. rough meadow-hay reduced to chaff, and 5 lbs. oil-cake, or value to that amount. They were divided into three lots, two in each. Lot 1 had 5 lbs. oil-cake for each animal; lot 2, barley and wheat-meal, equal in value to the 5 lbs. oil-cake; and lot 3, an equal money's worth of bruised linseed. The oil-cake cost £10 16s. per ton, the mixture of barley and wheat £8 15s. per ton, and the bruised linseed £13 per ton. The experiment lasted 112 days, and at its close the results, which proved very favorable to the bruised linseed, were as follows:—

	Increase in live weight.
Lot 1. Oil-cake	637 lbs.
Lot 2. Wheat and barley-meal... ...	667 lbs.
Lot 3. Bruised linseed	718 lbs.

During the 112 days each bullock consumed 5 cwt. oil-cake (or an equivalent amount of linseed or wheat and barley), 6 cwt. hay, and 90 cwt. of roots. The average increase in each animal's weight was 337 lbs. =224 lbs. *dead* weight. The economic features of this experiment are best shown in the following figures :—

FOOD CONSUMED.

	£	s.	d.
5 cwt. oil-cake, at 10s. 6d. per cwt. ...	2	12	6
6 cwt. hay, at 3s. per cwt.	0	18	0
16 weeks' attendance, at 6d. per week ...	0	8	0
	£3	18	6
Gained 16 stones per week, at 8s. per stone ...	6	8	0
Balance to pay for 90 cwt. of roots	2	9	6

The manure obtained afforded a good profit.

The seed-pods, or, as they are termed, the *bolls* of the flax, have been recommended as an excellent feeding stuff. They are not so nutritious as linseed, but they are cheaper, and when produced on the farm must be an economical food. Mr. Charley, an intelligent stock-feeder in the county of Antrim, and an eminent authority in every subject in relation to flax, strongly recommends the use of flax-bolls. He says :—

The cost of rippling is considerable ; but I believe, for every £1 expended, on an average a return is realised of £2, particularly on a farmstead where many horses and cattle are regularly kept. The flax-bolls contain much more nourishment than the linseed-cake from which the oil has, of course, been expressed, and they form a most valuable addition to the warm food prepared during winter for the animals just named. I believe they have also a highly beneficial effect in warding off internal disease, owing, no doubt, to the soothing and slightly purgative properties of the oil contained in the seed. The change made in the appearance of the animals receiving some of the bolls in their steamed food is very apparent after a few weeks' trial ; and the smoothness and sleekness of their shining coats plainly show the benefit derived. Is it not surprising, with this fact before our eyes, that many agriculturists—indeed, I fear the majority—persist in the old-fashioned system of taking the flax to a watering-place with its valuable freight of seed unremoved, and plunge the sheaves

under water, losing thereby, *in the most wanton manner*, rich feeding materials, worth from £1 to £3 per statute acre?

In the following table, the composition of all the more important oil-seeds is given:—

COMPOSITION OF OIL-SEEDS, ACCORDING TO DR. ANDERSON.

	Linseed.	Rape-seed.	Hemp-seed.	Cotton-seed (decorticated).
Water	7·50	7·13	6·47	6·57
Oil	34·00	36·81	31·84	31·24
Albuminous compounds (Flesh-formers)	24·44	21·50	22·60	31·86
Gum, mucilage, sugar, &c. ...	30·73	18·73	32·72	14·12
Woody-fibre		6·86		7·30
Mineral matter (ash)	3·33	8·97	6·37	8·91
	100·00	100·00	100·00	100·00

Fenugreek-seed is used very extensively in the preparation of "Condimental food." It is often given to horses out of condition. Sheep have been liberally supplied with this food, which, however, it is stated, communicates a disagreeable flavor to the mutton. It contains, according to Voelcker, the following:—

Water	11·994
Flesh-formers	26·665
Starch, gum, and pectin	37·111
Sugar	2·220
Fatty and oily matters	8·320
Woody fibre	10·820
Inorganic matter	2·870
	100·000

SECTION VII.

OIL-CAKES, AND OTHER ARTIFICIAL FOODS.

Oil-seeds, on being subjected to considerable pressure, part with a large proportion of their oil, the remaining part of that fluid, together with the various other ingredients of the seeds,

constitute the substances so well known to agriculturists under the name of oil-cakes. These cakes contain a larger proportion of ready-formed fatty matter than is found in any other feeding stuff, and an amount of flesh-forming principles far greater than that yielded by corn, or even by beans; the manure, too, which is produced by the cattle fed upon some of them, is often good value for nearly half the sum expended on the food.

The principal kinds of oil-cake employed for feeding purposes are the following:—Linseed-cake, Rape-cake, and cotton-seed cake. Poppy cake is not much in use. Their average composition, deduced from the results of numerous analyses made by Voelcker, Anderson, and myself, are shown in the following table:—

AVERAGE COMPOSITION OF OIL-CAKES.

	Linseed Cake, English.	Rape Cake.	Decorticated Cottonseed Cake.	Poppy Cake.
Water	12	11	9	12
Flesh-forming principles	28	30	38	32
Oil	10	11	13	6
Gum, mucilage, &c.	34	30	23	30
Woody fibre	10	10	9	9
Mineral matter (ash)	6	8	8	11
	100	100	100	100

Linseed Cake.—Within the last quarter of a century great attention has been given to the feeding of stock, and the effects are observable in the improved quality and greatly increased weight of the animals. In the year 1839 the average weight of the horned beasts from Ireland sold in the London market was only 650 lbs., whereas at the present time their average weight is about 740 lbs. This remarkable advance in the production of meat is in great part due to the cattle being more liberally supplied with food, and that, too, of a more concentrated nature. The practice of feeding

animals destined for the shambles exclusively on roots containing 90 and even 95 per cent. of water, which once prevailed so generally in this country, is now limited to the farmsteads of a few old-fashioned feeders; and the necessity for the admixture of highly-nutritious aliment with the bulky substances which form the staple food of stock is almost universally recognised.

Of concentrated foods used for fattening stock, none stands higher in the estimation of the farmer than linseed-cake, although it appears to me that the price of the article is somewhat too high in relation to its amount of nutriment, and that corn, if its price be moderate, is a more economical food. Straw, turnips, and mangels form the bone and sinew of the animals, and enable them to carry on the vital operations which are essential to their existence. Oil-cake and similar foods are supplemental, and contribute directly to the animal's increase, so that their nutritive value appears to be greater than it really is. If an animal were fed exclusively upon oil-cake, the greater part of it would be appropriated to the reparation of the waste of the body, and the rest would be converted into permanent flesh—the animal's "increase." The addition of straw would produce a still further increase in the animal's weight—an increase which would be directly proportionate to the amount of straw consumed. Thus it will be seen that, whatever the staple food may be, it will have to sustain the life of the animal, and will be principally expended for that purpose, whereas the supplemental food will be chiefly, if not entirely, made use of in increasing the weight of flesh. To me it appears manifestly incorrect to consider, as feeders practically do, the value of linseed-cake to be seven or eight times greater than that of oat-straw, and twenty times greater than that of roots. Let us assume the case of an animal fed upon roots, straw, and oil-cake. Seventy-five per cent. of its food, say, is expended in repairing the waste of its body, and 25 per cent. is stored up in its increase. Now, if the three kinds of food contributed proportionately to the reparation of

the body and to its increase, the roots and straw would be found to possess a far higher nutritive value, in relation to the oil-cake, than is usually ascribed to them.

But it may be asked why straw, if it be relatively a much more economical feeding stuff than oil-cake, is not employed to the complete exclusion of the latter. I have already given an answer to such a question, namely, that animals thrive better on a diet composed partly of bulky, partly of concentrated aliments. This much, however, is certain, that animals can be profitably fed upon roots and straw, whilst it is equally certain that to feed them upon oil-cake alone (assuming them to thrive upon such a diet) would entail a very heavy loss upon the feeder. At the same time it must be admitted that the oil of the linseed-cake exercises in all probability a beneficial influence on the digestion of the animal, so that the nutritive value of the article may be somewhat higher than its mere composition would indicate.

The quantity of oil-cake given to fattening stock varies from 2 lbs. to 14 lbs. per diem. I believe there is no greater mistake made by feeders than that of giving excessive quantities of this substance to stock. If their object in so doing be to enrich their manure-heap, they would find it far more economical to add the cake directly to the manure—or rather of adding rape-cake to it, for this variety of cake is fully as valuable for manurial purposes as the linseed-cake, and is nearly 50 per cent. cheaper. A larger quantity of oil-cake than 7 lbs. daily should not be given to even the largest-sized milch cows or fattening bullocks. If a larger amount be employed, it will pass unchanged through the animal's body. Young cattle may with advantage be supplied with from 1 to 3 lbs., according to their size, and from ½ to 1 lb. will be a sufficient quantity for sheep. Intelligent feeders have remarked, that cattle which had been always supplied with a moderate allowance of this food fattened more readily upon it, during their finishing stage, than did stock which had not been accustomed to its use.

Adulteration of Linseed Cake.—The great drawback to the use of linseed-cake is the liability of the article to be adulterated. The sophistication is sometimes of a harmless nature, if we except its injurious effect on the farmer's pocket; but not unfrequently the substances added to the cakes possess properties which completely unfit them to be used as food. Amongst the injurious substances found in linseed and linseed-cake I may mention the seeds of the purging-flax, darnel, spurry, corn-cockle, curcus-beans, and castor-oil beans. Several of these seeds are highly drastic purgatives, and they have been known to cause intense inflammation of the bowels of animals fed upon oil-cake, of which they composed but a small proportion. Amongst the adulterations of linseed-cake, which lower its nutritive value without imparting to it any injurious properties, are the seeds of the cereals and the grasses, bran, and flax-straw. Little black seeds belonging to various species of *Polygonum*, are very often present in even good cakes; they are very indigestible, but otherwise are not injurious. Rape-cake is stated to be occasionally used as adulterant of the more costly linseed, but I have never met with an admixture of the two articles.

The only way in which a correct estimate of the value of linseed-cake can be arrived at is by a combined microscopical and chemical analysis; but as the feeder is not always disposed to incur the cost of this process, he should make himself acquainted with the characteristic of the genuine cake, in order to be able to discriminate, as far as possible, between it and the sophisticated article. I will indicate a few of the more prominent features of cake of excellent quality, and point out a few simple and easily-performed tests, which may serve to detect the existence of gross adulteration. Good cake is hard, of a reddish-brown color, uniform in appearance, and possesses a rather pleasant flavor and odour. The adulterated cake is commonly of a greyish hue, and has a disagreeable odour. A weighed quantity of the cake—say 100 grains—in the state of powder should be formed into a paste with an ounce of water;

if it be good, the paste will be light colored, moderately stiff, and endowed with a pleasant odour and flavor. If the paste be thin, the presence of bran, or of grass seeds, is probable. The latter are easily seen through a magnifying-glass; indeed, most of them are readily recognisable by the unassisted eye: they may, therefore, be picked out, and their weight determined. Sand—a frequent adulterant—may be detected by mixing a small weighed quantity of the powdered cake with about twelve times its weight of water, allowing the mixture to stand for half an hour, and collecting and weighing the sand which will be found at the bottom of the vessel employed. If there be bran present it will be found lying on the sand, and its structure is sufficiently distinct to admit of its detection by a mere glance. There are a great variety of linseed-cakes in the market, of which the home-made article is the best. On the Continent the oil-seeds are subjected to the action of heat in order to obtain from them a greater yield of oil. Their cakes, therefore, contain less oil, and their flesh-forming principles are less soluble, in comparison with British linseed-cake. Next to ur home-made oil-cakes, the American is the best. Indeed, I have met with some American cakes which were equal to the best English.

Rape Cake.—The use of rape-cake was limited almost completely to the fertilising of the soil until the late Mr. Pusey, in a paper published in the tenth volume of the *Journal of the Royal Agricultural Society of England*, advocated its employment as a substitute for the more costly linseed-cake. The recommendation of this distinguished agriculturist has not been disregarded; and since his time the use of this cake as a feeding stuff has been steadily on the increase, and at the present time its annual consumption is not far short of 50,000 tons.

In relation to the nutritive value of rape-cake there exists considerable diversity of opinion. Certain feeders assert that animals fed upon it go out of condition; others, whilst admitting that stock thrive upon it, maintain the economic superiority of linseed-cake; whilst a third set believe rape-cake to be the

most economical of feeding-stuffs. How are we to account for these great differences of opinion—not amongst *theorists*, be it observed, but amongst practical men? It is not difficult to explain them away satisfactorily. Rape-cake and linseed-cake are about equally rich in muscle and fat-forming principles; and, supposing both to be equally well-flavored, there can be no doubt but that one is just as nourishing as the other. But it so happens that a large proportion of the rape-cake which comes into the British market possesses a flavor which renders it very disagreeable to animals. One variety—namely, the East Indian—is almost poisonous, whilst the very best kind is slightly inferior to linseed-cake. Now, if an experiment with a very inferior kind of rape-cake and a good variety of linseed-cake were tried, who can doubt but that the results would be very unfavorable to the former article? Mr. Callan,* of Rathfarnham, county Dublin; Mr. Bird,† of Renton Barns, and some other feeders, who found rape-cake to be worse than useless, experimented, in all probability, with an adulterated article, for they do not appear to have had the cake analysed. On the other hand, those whose experience with rape-cake has proved favorable, must have employed the article in a genuine state, fresh, and moderately well-flavored. It is noteworthy that amongst the advocates for the use of rape-cake as a substitute—partly or entirely—for the more costly linseed-cake, are to be found the most successful feeders in England and Scotland. Horsfall, Mechi, Lawrence, Bond, Hope, and many other feeders of equal celebrity, have assigned to rape-cake the highest place, in an economic point of view, amongst the concentrated feeding stuffs. Mr. Mechi says:—"I invariably give to all my animals as much rape-cake as they choose to eat, however abundant their roots or green food may be. It pays in many ways, and not to do this is a great pecuniary mistake. Even when fed on green rape, they will eat rape-

* *Monthly Agricultural Review*, Dublin, February, 1859.

† *Transactions of the Highland and Agricultural Society of Scotland*, October, 1858.

cake abundantly. My cattle are now under cover, eating the steamed chaff, rape-cake, malt-combs, and bran, all mixed together in strict accordance with the proportions named by Mr. Horsfall in the *Journal of the Royal Agricultural Society*, vol. xviii., p. 150,* which I find by far the most profitable mode of feeding bullocks and cows." Mr. Hope, of Edinburgh, states that rape-cake is the best substitute for turnips, and that, excepting cases where spurious kinds had been used, he never knew bullocks or milch cows to refuse it. This gentleman states that it is best given in combination with locust-beans, or a mixture of locust-beans and Indian corn; and suggests the proportions set down in the tables as the best adapted for lean cattle; but I think about two-thirds of the quantities would be quite sufficient.

	Feed per week. lbs.	Per week. *s.*	*d.*
Rape-cake at £5 15s. per ton	8	2	10½
Do. do.	10	3	7
Mixture of two-thirds rape-cake and one-third locust-beans £6	8	3	0
Do. do.	10	3	9
Rape-cake, locust-beans, and Indian corn in equal proportions	8	3	2½
Do. do.	10	3	11¼

An intelligent Scotch dairy farmer bears the following testimony in favor of this cake :—

I have tried pease-meal, bean-meal, oat-meal, and linseed-cake, and after carefully noting the results, I consider rape-cake, weight for weight, at least equal to any of them for milch cows; and if I give the same money value for each, I get at least one-third more produce, and the butter is always of a very superior quality. Two years ago, I took some of my best oats (41 lbs. per bushel), and ground them for the cows, and although I was at about one-third more expense, I lost fully one-third of the produce that I had by using rape-cake. I always dissolve it by pouring boiling water on it, and give each cow 6 lbs. daily. I have tried a larger quantity, and found I was fully repaid for the extra expense. I generally use it the

* 3 lbs. of rape-cake, ¾ lb. malt combs, ¾ lb. bran, steamed together with a sufficient quantity of straw.

most of the summer, but always during the spring months. A number of my neighbours who have tried it all agree that it is the best and cheapest feed for milch cows they have used.—*North British Agriculturist*, Edinburgh, February 29, 1860.

The best kinds of rape-cake come from Germany and Denmark. When neither too old nor too fresh, and of a pale-green color, these foreign cakes are tolerably well-flavored, and are but slightly inferior to good linseed-cake. Most varieties of this cake, however, contain a small proportion of acrid matter, which often renders them more or less distasteful to stock, more particularly to cattle. This substance may be rendered quite innocuous by steaming or boiling the cake; either of these processes will also, according to Mr. Lawrence, destroy the disagreeable flavor which mustard-seed—a frequent adulterant of rape-cake—confers upon that article. Molasses or treacle is an excellent adjunct to the cake, as it serves in a great measure to correct its somewhat unpleasant flavor. Carob, or locust-beans, answer, perhaps better, the same purpose. It is better, as a general rule, to give less rape-cake than linseed-cake, unless the pale-green kind to which I have referred is obtainable; that variety may be largely employed. The animals should be gradually accustomed to its use. At first, in the case of bullocks, they should get only 1 lb. per diem, and the quantity should be gradually increased to about 4 lbs.; but I would not advise, under any circumstances, a larger daily allowance than 5 lbs. Given in moderate amounts, it will, supposing it to be of fair quality, be found to give a better return in meat than almost any other kind of concentrated food; and, what is of great importance, it will not injuriously affect the animal's health. "Our experience of the use of rape-cake," says Mr. Lawrence, "thus used (cooked), extends over a period of ten years of feeding from 20 to 24 bullocks annually. We have not had a single death during that period, and the animals have been remarkably free from any kind of ailment."

Rape-cake of good quality possesses a dark-green color

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(the greener the better), and when broken exhibits a mottled aspect—yellowish and dark-brown spots. Sometimes a tolerably good specimen has a brownish color; but the German and Danish cakes are always of a greenish hue. The odor is stronger than that of linseed-cake, and differs but little from that of rape-oil. The only serious adulteration of rape-cake is the addition to it of mustard-seed—sometimes accidentally—less frequently, as I believe, intentionally. This sophistication admits of easy detection. Scrape into small particles about half an ounce of the cake, add six times its weight of water, form the solid and liquid into a paste, and allow the mixture to stand for a few hours. If the cake contain mustard the characteristic odor of that substance will be evolved, and its intensity will afford a rough indication of the amount of the adulterant. As some specimens of genuine rape-cake possess a somewhat pungent odor, care must be taken not to confound it with that of mustard; but, indeed, it is not difficult to discriminate the latter. The paste of rape-cake which contains an injurious proportion of mustard, has a very pungent flavor. Rape-cake improves somewhat if kept for say six months; but old cake is worse than the fresh article.

Cotton-seed Cake is one of the most valuable feeding stuffs that have come into use of late years. Its chemical composition shows it to be about equal to that of the best linseed-cake, and as its price is much lower than that of the latter, it may be fairly considered a more economical food. These remarks apply only to the shelled, or decorticated seed-cake, for the article prepared from the whole seed is of very inferior composition, and should never be employed. The use of the cake made from the whole seed has proved fatal in many instances, not from its possessing any poisonous quality, but in consequence of its hard, indigestible husk, accumulating in, and inflaming, the animal's bowels.

The composition of this cake varies somewhat. The following analysis of a sample from one of the Western States of

North America, imported by Messrs. G. Seagrave and Co., of Liverpool, was made by me :—

COMPOSITION OF DECORTICATED COTTON-SEED CAKE.

Water	8·20
Oil	10·16
Albuminous, or flesh-forming principles ...	40·25
Gum, sugar, &c.	21·10
Fibre	9·23
Ash (mineral matter)	11·06
	100·00

In some specimens so much as 16 per cent. of oil has been found. The purchaser of cotton-seed cake should be certain that it is not old and mouldy, which is frequently the case. The recently prepared cake has a very yellow color, which becomes fainter as the cake becomes older. Freshness is a very desirable quality in nearly every kind of cake. I have known animals to have a greater relish for, and thrive better upon, home-made linseed-cake than upon cake of foreign manufacture of superior composition, but of greater age.

Palm-nut Meal, or Cake is a very valuable fattening food. It is extremely rich in ready-formed fatty matters, but at the same time it is not very deficient in albuminous substances. Its strong flavor is rather a drawback to its use in the case of all the farm animals, except pigs. This difficulty may, however, be got over by using the cake in moderate quantities, and by combining it with other food possessed of a good flavor. Reports of practical trials made with this food appear to have almost uniformly given very favorable results. This food is only three or four years in use. The first samples that came into my hand were richer in fatty matters than those which I have recently examined. The average results of eight analyses made from 1864 to 1866 were as follows :—

100 PARTS CONTAINED—

Water	7·48
Albuminous matters	17·26
Fatty substances	21·59
Gum, sugar, &c.	32·14
Fibre	17·18
Mineral matter	4·35
	100·00

This year I have not found more than 17 per cent. of fat in any sample of palm-nut cake. One specimen which I analysed for Mr. J. G. Alexander, seed merchant, of Dublin, had the following composition :—

Water	9·24
Albuminous matters	19·28
Fatty matters	9·36
Gum, starch, fibre, &c.	53·22
Mineral matters	8·90
	100·00

But although inferior samples are occasionally met with, I may say of palm-nut cake that on the whole it is a food which deserves to be largely used, and which at its present price is the most economical source of fat. To milch-cows and fattening cattle about 3 lbs. per diem may be given; ¼ lb. will be sufficient for young sheep, whilst pigs may be very liberally supplied with this food.

The *Locust, or Carob Bean*, is now largely used by the stock-feeder. It is extremely rich in sugar, and is therefore an excellent fattening and milk-producing food. It is used largely in the preparation of the sweet kinds of artificial food for cattle. It is not well adapted for young animals, owing to its deficiency of albuminous matters. The following analysis shows the average composition of this food :—

Water ...	14
Sugar ...	50
Albuminous matters ...	8
Oil ...	1
Gum, &c. ...	20
Woody fibre ...	5
Ash ...	2
	100

Dates have been used, but only in very small quantities, as cattle food. Their composition is not constant, some samples being greatly inferior in nutritive power to others; they are rich in sugar, and if they were obtained in sufficient quantities they might, like carob-beans, come into general use with the stock-feeder. They contain about 2 per cent. of flesh-formers. 10 per cent. of fat-formers (chiefly sugar), and 2 per cent. of mineral matter.

Distillery and brewery dregs (or wash) are chiefly used by dairymen. According to Dr. Anderson, an imperial gallon (700,000 grains) of distillery wash (from a distillery near Edinburgh) contained 4,130 grains of organic matter, and 276 grains of mineral substances. He considers that 15 gallons of this stuff were equal in nutritive materials to 100 pounds of turnips. The following is the centesimal composition of brewery wash:—

Water ...	75·85
Albuminous matters ...	0·62
Gummy matters ...	1·06
Other organic matter (husks, &c.) ...	21·28
Mineral matters ...	1·19
	100·00

Molasses constitute a very fattening food, sometimes, but not often, given to stock. Treacle and molasses are composed of non-crystallisable sugar, cane-sugar, water, and saline and other impurities. The composition of average specimens of molasses, as imported, is as follows:—

Cane-sugar	50
Non-crystallisable sugar and grape-sugar	25
Water, saline matter, and organic impurities	25
	100

If admitted duty free, molasses would be a much more economical food than it now is, but at its present price it must be regarded as a mere flavoring food.

Mr. T. Cooke Burroughs, a West Suffolk feeder, who used treacle in 1864, gives the following mode of mixing it with other food :—

My plan has been (and is still carried on) to give to each bullock per day (divided into three meals) one pint of treacle dissolved in two gallons of water, and sprinkled, by means of a garden water-pot, over four bushels of cut chaff (two-thirds straw and one-third hay) amongst which a quarter of a peck of meal (barley and wheat) is mixed, the animals also having free access to water. The cost of the treacle and meal together is about 3s. per bullock per week. My bullocks (two-year old Shorthorns) have grown and thrived upon the above diet to my utmost satisfaction; and even during the present dry and warm weather they evince no lingering after roots or grass. I am well aware that the use of treacle for neat stock is no new discovery of my own, as I learnt the system while on a visit to a friend in Norfolk, where some graziers have used it in combination with roots during many years past. Perhaps flax-seed (linseed) boiled into a jelly and used in a similar way, may be a more profitable "substitute for roots" than treacle; but the preparation of it is attended with more expense and trouble.

SECTION VIII.

CONDIMENTAL FOOD.

ALTHOUGH every farmer may not have used, there are few who have not heard of "Thorley's Condimental Food for Cattle." This nostrum is a compound of some of the ordinary foods with certain well-known aromatic and carminative substances. It possesses a very agreeable flavor, and it is there-

fore much relished by horses, and indeed by every kind of stock. The price of this compound was at first so much as £60 per ton; but owing to competition, and perhaps to the attacks made upon the enormously high price of this article, it is now to be obtained at prices varying from £12 to £24 per ton.

The inventor of condimental food, and the numerous fabricators of that compound, claim for it merits of no ordinary nature. Its use, they assert, not only maintains the animals fed upon it in excellent health, but it also exercises so remarkable an action upon the adipose tissues that fat accumulates to an immense extent. Moreover, it is said that an animal supplied with a very moderate daily modicum of this wonderful compound, will consume less of its ordinary food, though rapidly becoming fat.

Now, if these assertions were perfectly, or even approximatively, true, Mr. Thorley would be well deserving of a niche in the temple of fame, and stock-feeders would ever regard him as a benefactor to his own and the bovine species; but I fear that Mr. Thorley's imagination outstripped his reason when he described in such glowing terms the wonderful virtues of his tonic food.

Mr. J. B. Lawes, of Rothamstead, than whom there is no more accurate experimenter in agricultural practice, states that he made many careful trials with Thorley's food, and that he never found it to exercise the slightest influence upon the nutrition of the animals fed upon it. In his report upon this subject, Mr. Lawes, after describing the experiments which he made, sums up as follows:—

There is nothing therefore in the above results to recommend the use of Thorley's condiment with inferior fattening food, to those who feed pigs for profit. In fact, the following balance-sheet of the experiment shows that, in fattening for twelve weeks, there was a balance of £1 10s. 11d. in favor of the lot fed without Thorley's food, notwithstanding that one of the pigs in that lot did badly throughout the experiment, as above stated.

LOT 1.—WITH BARLEY-MEAL AND BRAN.

	£	s.	d.
4 pigs bought in at 41s. 6d. each	8	6	0
1,860¾ lbs. barley, at 37s. 6d. per quarter of 416 lbs., including grinding...	8	7	8¾
1,024¾ lbs. bran at 5s. 6d. per cwt.	2	10	3¾
	19	4	0½
88 stone 5 lbs. of pork sold at 4s. 4d. per stone, sinking the offal	19	4	0½

LOT 2.—WITH BARLEY-MEAL, BRAN, AND THORLEY'S FOOD.

	£	s.	d.
4 pigs bought in at 41s. 6d. each	8	6	0
1,862¾ lbs. barley, at 37s. 6d. per quarter of 416 lbs., including grinding	8	7	10¼
1,020¾ lbs. bran at 5s. 6d. per cwt.	2	10	1½
105 lbs. Thorley's food at 40s. per cwt.	1	17	6
	21	1	5¾
90 stone 1 lb pork sold at 4s 4d. per stone, sinking the offal	19	10	6½
	1	10	11¼

The results of these experiments with pigs, in which Thorley's condiment was used with inferior fattening food, may be summed up as follows:—

1. The addition of Thorley's condimental food increased the amount of food consumed by a given weight of animal within a given time.

2. When Thorley's condiment was given it required more food to produce a given amount of increase in live-weight.

3. In fattening for twelve weeks there was a difference of £1 10s. 11d. on the lot of 4 pigs in favor of barley-meal and bran alone, over barley-meal, bran, and Thorley's food in addition.

At a meeting of the Council of the Royal Agricultural Society of England, held some time ago, the subject of the nutrimental value of condimental cattle food was discussed. As there is scarcely any kind of quackery, from spirit manifestations to Holloway's pills, that has not got its believers, there were, as might have been anticipated, some voices raised at this meeting in favor of Thorley's food; but the *sense* of the meeting was decidedly against it. Professor Simonds pronounced it to be worthless.

Although the greater number of equine proprietors and feeders of stock are too sensible to throw their money away in the purchase of those costly foods, still there are by no means an insignificant number who employ it, under the idea that it preserves the health of the animals ; these stuffs are also highly appreciated by many grooms and herds. Now, for the information of all believers, I may state that there is no mystery whatever in the nature of condimental cattle foods. They consist in substance of such matters as linseed-cake, Indian corn, rice, bean-meal, locust-beans, and malt-combings. These substances are flavored by the addition of turmeric-root, ginger, coriander-seed, carraway-seed, fenugreek-seed, aniseed, liquorice, and similar substances. In addition to the nutritive and flavorous articles employed in the manufacture of these foods, purely medicinal substances are also made use of with the idea that they would prove useful in maintaining the health and stimulating the appetite of the animals. These medicinal ingredients constitute but a small proportion of the compound, although they add considerably to the cost of manufacture. The following is a formula for a condimental food, which in every respect will be found fully equal, if not superior, to the ordinary high-priced articles.

	cwt.	qrs.	lbs.
Linseed-meal, or cake	7	0	0
Locust beans (ground)	8	0	0
Indian corn	4	1	0
Powdered turmeric	0	1	4
Ginger	0	0	3
Fenugreek-seed	0	0	2
Gentian	0	0	10
Cream of tartar	0	0	2
Sulphur	0	0	20
Common salt	0	0	10
Coriander-seed	0	0	5
	One ton.		

A ton of condimental food manufactured according to this formula will cost only about the same amount as an equal

weight of linseed, and will produce an effect fully equal to that of the food which at one time was sold at £60 per ton.

Whatever may be the medicinal virtues of these foods, or however appropriate the term "condimental" which has been applied to them, it is quite certain that their whilom designation "concentrated" was a misnomer. Their composition shows that they possess a degree of nutritive power considerably below that of linseed-cake, and but little, if at all, superior to that of Indian corn.

The following analytical statement, which I published some years ago, will give an insight into the nature of these articles :—

ANALYSES OF CONDIMENTAL FOOD.

	Thorley's.	Bradley's.
Water	12·00	12·09
Nitrogenous, or flesh-forming principles	14·92	10·36
Oil	6·08	5·80
Gum, sugar, mucilage, &c.	56·86	60·21
Woody fibre	5·46	5·32
Mineral matter (ash)	4·68	6·22
	100·00	100·00

As a ton of linseed-cake contains a greater amount of nutriment than an equal quantity of condimental food, the latter should be clearly proved to possess very valuable specific virtues, in order to induce the feeder to use it extensively. Cattle and horses out of condition may be benefited by its carminative and tonic properties; but if they are, it surely must be a bad practice to feed healthy animals upon a substance which is a remedy in disease. It is asserted, and probably with some degree of truth, that when dainty, over-fed stock loathe their food, they are induced to eat greedily by mixing the "condimental" with their ordinary food. If such really be the case, let the feeder compound the article himself, and effect thereby a saving of perhaps 50 or 80 per cent. in the cost of it. A good condimental food, rich in actual nutriment, and pleasantly flavored, is no doubt a compound which might be used with advantage; but it should be sold at a moderate and fair price.

SECTION IX.—ANALYSES OF THE ASHES OF PLANTS.

(Extracted from the Author's "Chemistry of Agriculture.")

Those numbers marked with an asterisk refer to 100 parts of the substance in its natural or undried state; the remaining numbers refer to 100 parts when dried.

	Rape Seed.	Flax.		Peas.	Kidney Beans.	White Turnip Seed.	Turnip Bulb (Swede).	Cucumber.	Mangel Wurtzel Seed.	Potatoes (tubers).	Hop Flowers.
		Stalk.	Seed.								
Potash	25·18	34·96	32·55	43·09	36·83	21·91	39·82	47·52	16·08	35·15	19·41
Soda	...	...	2·51	...	18·40	1·23	10·86	...	6·86	5·77	0·70
Lime	12·91	15·87	9·45	4·77	7·75	17·40	12·75	6·31	13·42	2·14	14·15
Magnesia	11·39	3·68	16·23	8·06	6·33	8·74	4·68	4·26	15·22	2·69	5·34
Sesquioxide of Iron ...	0·62	4·84	0·38	...	2·24	1·95	0·89	...	0·40	1·79	2·41
,, Manganese	...	...	...	...	...	...	...	...	...	...	...
Sulphuric Acid	0·53	4·99	1·43	0·44	3·96	7·10	13·15	4·60	3·64	3·29	8·28
Muriatic Acid	0·11	...	...	1·96	...	...	3·68	...	...	...	2·26
Carbonic Acid	2·20	13·39	...	...	...	0·82	...	...	13·85	17·14	11·01
Phosphoric Acid	45·95	8·48	35·99	40·56	11·60	40·17	6·69	18·03	13·35	20·70	14·64
Silica	1·11	5·60	1·46	0·79	4·09	0·67	7·05	7·12	1·86	3·00	18·56
Chloride of Potassium...	...	7·65	...	...	...	...	...	4·19	...	1·84	...
Chloride of Sodium ...	...	0·54	...	...	2·80	...	...	9·06	15·30	6·49	2·95
Total	100·00	100·00	100·00	99·67	100·00	99·99	99·57	100·09	99·98	100·00	99·71
Per-centage of Ash ...	4·51	5·00	3·05	5·21	0·68*	3·98	7·60	0·63*	6·58		6·05

ANALYSES OF THE ASHES OF PLANTS.

The number marked with an asterisk refers to 100 parts of the substance in its natural or undried state; the remaining numbers refer to 100 parts when dried.

	Cauli-flowers.	Hopeton Oats (Grain).	Potato Oats (Grain).	Husks of Potato Oats.	Rye.		Hay.	Grasses (in flower).			
					Grain.	Straw.		Bromus erectus.	Lolium perenne.	Annual Rye-grass.	Avena flavescens.
Potash	34·39	20·65	31·56	2·23	31·76	17·36	20·80	20·33	24·67	28·99	36·06
Soda	14·79	...		8·97	4·45	0·31	10·85	...	...	0·87	0·73
Lime	2·96	10·28	5·32	4·30	2·92	9·06	8·24	10·38	9·64	6·82	7·98
Magnesia	2·38	7·82	8·69	2·35	10·13	2·41	4·01	4·99	2·85	2·59	3·07
Sesquioxide of Iron ...	1·69	3·85	0·88	0·32	0·82	1·36	1·83	0·26	0·21	0·28	2·40
,, Manganese	...	0·42	...	...	...	...	...	...	...	...	...
Sulphuric Acid	11·16	...	...	4·30	1·46	0·83	2·11	5·46	5·20	3·45	4·00
Muriatic Acid	...	...	...	...	...	0·46	...	...	...	...	...
Carbonic Acid	...	...	...	...	...	...	0·68	0·55	0·49	...	...
Phosphoric Acid	27·85	50·44	49·19	0·66	47·29	3·82	15·43	7·53	8·73	10·07	9·31
Silica	1·92	4·40	1·87	74·18	0·17	64·50	30·01	38·48	27·13	41·79	35·20
Chloride of Potassium ...	...	1·03	...	...	...	...	...	10·63	13·80	...	...
Chloride of Sodium ...	2·86	...	0·35	2·39	...	...	5·09	1·38	7·25	5·11	1·25
Total	100·00	98·89	97·86	99·70	100·00	100·11	99·05	99·99	99·97	99·97	100·00
Per-centage of Ash ...	0·71*		2·22		2·30	2·60		5·21	7·54	6·45	5·20

ANALYSES OF THE ASHES OF PLANTS.

Those numbers marked with an asterisk refer to 100 parts of the substance in its natural or undried state; the remaining numbers refer to 100 parts when dried.

	Broccoli.		Cow Cabbage.		Kohl-rabi, from chalk soil.		Wheat (Grain).	Wheat.		Barley.	
	Root.	Leaves.	Leaves.	Stalk.	Leaves.	Tuber.		Grain.	Straw.	Grain.	Straw.
Potash	47·16	22·10	40·86	40·93	9·31	36·27	29·51	25·92	10·78	32·02	14·37
Soda	...	7·55	2·43	4·05	...	2·84	10·61	...	...	1·21	0·28
Lime	4·70	28·44	15·01	10·61	30·31	10·20	0·99	3·80	2·44	3·39	8·50
Magnesia	3·93	3·43	2·39	3·85	3·62	2·36	10·60	12·27	3·23	10·99	1·70
Sesquioxide of Iron ...	...	...	0·77	0·41	5·50	0·38	...	1·12	0·54	0·15	0·20
,, Manganese	...	...	...	...	...	...	...	...	...	...	...
Sulphuric Acid	10·35	16·10	7·27	11·11	10·63	11·43	0·09	...	1·77	...	2·22
Muriatic Acid	...	...	...	...	...	...	...	...	...	...	...
Carbonic Acid	...	...	16·68	6·33	8·97	10·24	...	4·43	6·01	0·48	1·25
Phosphoric Acid	25·83	19·81	12·52	19·57	9·43	13·46	47·55	43·44	3·69	29·92	4·22
Silica	1·81	2·83	1·66	1·04	9·57	0·82	0·11	7·16	64·84	21·12	62·89
Chloride of Potassium...	6·22	...	...	...	5·99	...	...	1·03	3·96	...	...
Chloride of Sodium ...	a trace	...	...	2·08	6·66	11·90	0·54	...	0·42	0·72	4·37
Total	100·00	100·26	99·99	99·98	99·99	99·90	100·00	99·17	99·68	100·00	100·00
Per-centage of Ash ...	1·01*	1·70*	0·70*	1·24*	18·54	8·09	2·32	1·645	5·252	2·22	5·49

APPENDIX.

WHILST this Work was passing through the press, a valuable Report on Agricultural Statistics was issued by the Board of Trade. The following statistics, collected from this Report, are here given, because they modify the statements made in page 5 :—

POPULATION, AREA, ACREAGE UNDER CROPS, ETC., AND NUMBER OF LIVE STOCK, IN THE UNITED KINGDOM IN 1867.

	England.	Wales.	Scotland.	Ireland.	Isle of Man.	Channel Islands.		Total for United Kingdom
						Jersey.	Guern-sey, &c.	
Population (1866)	20,276,494	1,187,103	3,136,057	5,571,971	52,469	55,613	35,365	30,315,072
Area (in Statute Acres)	32,590,397	4,734,486	19,639,377	20,322,641	180,000	28,717	17,967	77,513,585
Under Corn Crops	7,399,347	521,404	1,364,029	2,115,137	27,039	2,827	2,157	11,431,940
,, Green Crops	2,691,734	138,387	668,042	1,432,252	12,670	5,636	3,075	4,951,796
,, Bare Fallow	753,210	86,257	83,091	26,191	1,990	2,550	709	953,998
,, Grass—Clover, &c., under Rotation	2,478,117	300,756	1,211,101	1,658,451	26,884	3,250	874	5,679,433
Permanent Pasture, not broken up in Rotation*	9,545,675	1,472,359	1,053,285	10,057,072	15,915	6,092	6,143	22,156,541
Per-centage of Acreage : †—								
Under Corn Crops	32·3	20·7	31·1	13·6	32·0	13·9	16·7	25·1
,, Green Crops	11·7	5·5	15·3	9·2	15·0	27·6	23·7	10·9
,, Bare Fallow	3·3	3·4	1·9	·2	2·4	12·5	5·5	2·1
,, Grass—Clover,&c.,underRotation	10·8	11·9	27·7	10·7	31·8	16·0	6·7	12·4
Permanent Pasture‡	41·6	58·5	24·0	64·7	18·8	30·0	47·4	48·7
Number of Cattle	3,469,026	544,538	979,470	3,702,378	18,672	10,081	7,308	8,731,473
,, of Sheep	19,798,337	2,227,161	6,893,603	4,826,015	70,958	529	1,348	33,817,951
,, of Pigs	2,548,755	229,917	188,307	1,233,893	7,706	5,804	6,718	4,221,100
Number of Live Stock to every 100 Acres under Crops, Fallow, and Grass :—								
Cattle	15·1	21·6	[illegible]2·4	23·8	22·1	49·5	56·4	19·2
Sheep	86·3	88·4	157·4	31·1	84·0	2·6	10·4	74·3
Pigs	11·1	9·1	4·3	7·9	9·1	28·5	51·8	9·3

* Exclusive of heath or mountain land. † The per-centage of acreage is exclusive of Hops in Great Britain, and Flax in Ireland.
‡ Including under Flax, 253,105 acres.